[Established 1832]

THE OLDEST RAILROAD JOURNAL IN THE WORLD

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE (INC.)

140 NASSAU STREET, NEW YORK

J. S. BONSALL, Vice-President and General Manager

F. H. THOMPSON, Eastern Advertising Manager.

Editors:

E. A. AVERILL. **OSCAR KUENZEL.**

MAY, 1910

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THE FUEL DEPARTMENT.

Practically all appliances that are invented for locomotives base their claim for recognition upon their direct or indirect ability to save fuel. The proof that an appliance will save a ton of coal a day can be formed into a very convincing argument for its general application, and in fact most of the new appliances or new designs of locomotives have come into general use largely because of their fuel-saving ability. Every one recognizes the enormous money value of a small saving on the fuel consumption of each locomotive and every one will take the time to carefully consider any device which promises results in this direction.

In view of this, it seems inconsistent that so few railroad companies have a thoroughly organized and efficient fuel department, which beyond doubt, by its mere ability to discover unnecessary losses, will be able to show a net saving that will far exceed the saving of all the different appliances that could possibly be put on to a locomotive. There are very few railroad systems which do not offer a field for a complete and even elaborate fuel department. Where such a department has been organized it has brought to light entirely unsuspected leaks and been able to institute economies in unthought of directions that often much more than pay its total expense.

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The secret of the results that are being obtained lies very largely in two things: first, personnel, and second, methods. The largest factor in the latter is the designing of a system of reports and of records which will give the maximum amount of really valuable information with the minimum delay and the least amount of clerical work. Having drawn up a suitable series of forms for reports and records a very large part of the foundation of the department has been finished. If these are suited to the conditions in every respect and are in charge of properly qualified officers, the success of the department is practically assured at the start.

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A GENERAL LOCOMOTIVE INSPECTION.

AN ACCOUNT OF THE METHOD OF PROCEDURE, SOME OF THE RESULTS AND THE CONCLUSIONS FOLLOWING A DETAILED INDIVIDUAL INSPECTION OF OVER FIFTEEN HUNDRED LOCOMOTIVES OF ALL TYPES AND SIZES.

By R. H. Rogers.

IN THREE PARTS. PART I—SCOPE AND METHODS.

In September, 1908, it was decided by the management of one of the large railroad systems (hereafter called the A. B. C. R. R.) to have a special inspection made of each and every locomotive owned or leased by that system, and the writer, through its general mechanical superintendent, was deputed for the work. The assignment was formidable, as the fifteen hundred and odd engines were scattered over one thousand miles of straight main line and on diversified branches, which brought the total mileage to 2,406 miles. The number of divisions, each under a master mechanic, was twelve; but the roundhouses which must be visited incidental to the inspection aggregated forty-four, not to mention some dozen or more isolated points without roundhouse facilities, but where nevertheless switching and work train engines were employed.

The reasons which prompted the inspection have never been entirely clear to the writer. It was on a scale of such magnitude as to render the procedure practically without a precedent, and it is unfortunate through this singularity alone that the motive is obscure. It has been suggested that the thought arose primarily through a criticism offered by one of the outside building shops, following an instance where the railroad company objected to an excessive bill for repairs to some of its engines. This building shop, in excuse or explanation, is said to have advanced that the high cost was due to the fact that the engines were in a distressingly run down condition when received at the works, worse in this regard than any repairs heretofore contracted for. This is supposed to have rankled the management to the extent that an inspection for self-advisement logically followed.

Although with merely speculation as a basis the writer does not think that the unique assignment was so inspired. The power, as a whole, on the A. B. C. Railroad had for some time previous been the subject of much unjust oral and written criticism, and the portrayal of presumed conditions through the latter medium embodied an equal mixture of aspersion and levity. It was erroneously asserted, or at least implied, that the engines were generally unserviceable, and that the unfortunate schedule irregularities of the period were due more to their poor condition than any other cause. It is therefore the belief of the inspector that to disprove this clamor, or at least satisfy himself through a disinterested observer, the general mechanical superintendent determined to have each locomotive carefully examined, although it was self-evident that several months at least must be consumed in the undertaking. The thought is also present that he wished to know personally how the locomotives of the A. B. C. Railroad compared with those of other large roads with which the inspector had been connected in the past.

It is fitting to say here that no matter who or what may have dictated the inspection, the attitude of this official throughout implied simply the desire to get at the facts, whether detrimental to his administration or the reverse, and his encouragement and appreciation extended from time to time as the rather trying assignment progressed, served to temper many a weary day with its accompaniment of ice bound ash pits and the gloomy and damp environment of roundhouses in the dead of the winter season.

The general conclusions reached in the final report of the inspection, independent of the motives which brought it about, must have been gratifying to the management of the A. B. C. Railroad. In fact, long before the wind up, the reports which reached the general offices weekly from the inspector on the line had steadily developed the fact that far from being inefficient, the general run of the locomotives were above the average of efficiency. In fact, the recapitulation of all reports submitted showed an even seventy-eight per cent. of the total power as efficient. This, it may be added, was four points higher than in the instance of two other large systems whereon the writer was connected with a somewhat similar inspection. It was an eminently fair summary, as the inspector was an entire stranger to the road and its division management, and through this unfamiliarity had not a single axe to grind. He was paid merely to narrate conditions as they appeared to him, and the freedom was allowed, or at least not objected to in his reports, to draw whatever inferences might suggest from the notes at hand.

In order that freedom from the slightest imputation of unfairness be assured in connection with the inspection, certain requisites were self-evident for the person selected to make it. Primarily, it was appreciated that he should not be identified with any division of the A. B. C. Railroad, as absolute impartiality must prevail in his reports to endow them with the comparative value per division, which was especially desired, and he must necessarily have thorough familiarity with locomotive conditions as they should be for efficiency, in addition to possessing a general knowledge of up-to-date practises in repairs to parts.

The first, and most difficult of these conditions, was happily realized in the instance of the writer, who, previous to the assignment, had traveled but sixteen miles over this railroad, and had yet to see the first of its shops or roundhouses. He was equally unacquainted with the supervision of any shop, or its workmen, on each of the various divisions from the first to the last, and unfamiliar with the power as well, except in the instance of a dozen or more A. B. C. engines which had been sent for general repairs to one of the outside locomotive building shops where he happened to be stationed as inspector. This general unfamiliarity with the situation, no doubt, appealed to the A. B. C. management through its implied assurance of fairness, and this latter was, of course, the great end to be desired. In the very brief instructions given before starting out it was plainly apparent that all desired in his reports was a comparison between a locomotive as it should be with existing locomotive conditions on the A. B. C. Railroad, the conclusions to be voiced without fear or favor.

Naturally the inspection, conducted under the favorable auspices of absolute freedom from interference with the inspector, which the management faithfully observed from start to finish, resulted in bringing to light a wealth of interesting detail. The continuous examination of over fifteen hundred locomotives served to establish truisms for many speculations which had before prevailed in accounting for the wear of parts. In view of the well ordered organization of the present day, from which by no means was the A. B. C. Railroad exempt, it is astonishing that there could be so much diversity in locomotive deterioration which its respective divisions exhibited, and the inspection not only established the presence of divergent mechanical procedure,

but brought to light as well singular and unsuspected personal features in connection with locomotive maintenance. It is thought advisable, however, to confine this particular article to an explanation of the ends intended by the inspection, and of the plan decided upon to report its details, reserving what was found while on the road, and its lessons, for subsequent presentations.

The consideration of forms on which to report the condition of the various engines examined was abandoned practically in the incipiency of the idea. It was rightly viewed that these, no matter how elaborate in scope, or in multiplicity of items, would not graphically portray the conditions, and furthermore would naturally tend to restrict the inspector's inquiry to their several items. In fact, after the inspection had been completed, the general mechanical superintendent explained that it had been his particular desire for the inspector to assume the initiative throughout. This serves to explain the absence of forms, or report blanks, and to account for the brevity of the original assignment, which was practically without instructions.

As a preliminary to starting the work two problems were presented which must necessarily be solved before the first locomotive was looked over and reported on, this in order that uniformity be secured through the entire bulk of reports, and no move was made until these had been decided upon. It was readily appreciated that there could be no deviation from a procedure once inaugurated. The first of these, which became the subject of much reflection, was how best to report each separate engine, as routine reports or forms were tabooed; and second, how to broadly define the general condition of each locomotive on the reports for the information of the mechanical superintendent, and for use in the final summary of each division.

In the consideration of the first item it was assumed that a detail inspection report, such as a roundhouse inspector would return to his superior, was out of the question, and this largely because the reports of a general inspection must be made to the head of the motive power department direct, who through the demand on his time should not be burdened with the review of nuts off bolts, or cotters lost from brake rigging pins. Not disputing that these reports are indispensable in roundhouse organization, they were not considered of sufficient importance in this connection to warrant presentation, hence it became a requisite to evolve a scheme for the conduct of this inspection on broader and more significant lines than are employed in roundhouse or local procedure.

It was resolved to confine strictly to what implies locomotive deterioration in its true application; that is, the features of deterioration which are practically beyond the resources of an ordinary roundhouse to correct, or if not beyond it, are still through time-honored precedent, allowed to remain in evidence until the engine must be taken in for general repairs. From this viewpoint the inspection must then omit the smaller items in need of repair, notwithstanding in many instances that it effectually indicated the crying need for a remedy.

It was concluded, or assumed by the inspector, that such minor detrimental conditions as a rod brass in need of reducing; a driving spring rubbing the fire-box; an injector branch pipe leaking, or a tank hose requiring a new nut, would be reached and corrected in due season by the roundhouse foreman. Through the same reasoning it did not appeal as necessary to mention blows in valves or cylinder packing, or even comment on engines with valves out of square, as, properly viewed, none of these are active elements in deterioration, because they must perforce be immediately corrected in recognition of the conceded locomotive inefficiency present under such conditions.

In the interest of harmony and good feeling the inspector decided after due reflection to make direct mention of such items to the division supervision in the territory where they were noticed, and their omission from his report to the general mechanical superintendent did not in any way detract from the value of the information which the latter was looking to secure. The writer believes that much good resulted following this practice. The master mechanics appreciated that they were being given at least an "even break," and that there was no desire on the part of the inspector to parade faults before the management that could be controlled on the division.

After thus expurgating details the points to be enumerated in the inspection resolved first into the condition of the tires, and particularly in reference to sharp flanges; second, the amount of end play or lateral motion present, whether in engine truck or driving boxes; third, the consideration of broken parts, whether frames, wheel centers, cylinders, or the less important members; and fourth, an analysis of neglect on the part of the local supervision to maintain the engine, tempered, of course, by an inquiry into their existing facilities to do so.

The reports on each engine, therefore, assumed the form of notes, ranging in length from ten to three hundred or more words, and the individual examinations were made with the above synopsis ever present in the mind of the inspector as a working basis.

The second problem which must be solved before any real work could be done, viz., the proper definition of the condition of the engine as indicated by the inspection above outlined, embodied at least the postulate that each one must be termed "good" or "poor." It was thought best, however, to oppose an intermediary between these extreme designations; hence all were defined as "good," "fair" or "poor." In advising the general mechanical superintendents of this decision before forwarding any reports the following conditions were adopted as governing the application of the three terms.

Good engines to be those which would apparently run for at least six months, as indicated by the inspection, without recourse to other than running or roundhouse repairs.

Fair engines to be those which the inspection discloses will not run six months without receiving heavier repairs than the roundhouse can give.

Poor engines to be those no longer fit for service, through generally worn parts, or the presence of manifestly improper conditions, such as broken frames, in particular; and, with more conservatism, cracked wheel centers, etc.

It is agreed that this plan for defining power is open to criticism, but as well this as any other in view of the generally admitted fact that there is no standard scheme for arriving at such conclusions. The separate divisions of a single railroad, which the inspection disclosed in this instance, are at the utmost variance in their interpretation of forms intended to be self-explanatory in reporting conditions. On the majority of roads, including the A. B. C. Railroad, there is a standard form to be forwarded by the master mechanic on the first of the month, one for each locomotive under his jurisdiction, and presumably adequate to define the condition of the engine for ready appreciation. These forms, as a rule, embody considerable detail in enumerating the parts most susceptible to wear. Opposite the various items an explanatory symbol is placed by the person making them out; for instance, "X" implies perfection; the figure "1," very good; "2," good; "3," fair; "4," poor, and "5," very poor.

If one man so valued the different items for every engine on the railroad, these forms would be of comparative value, but through the conditions under which they are generally compiled, they are practically worthless from that standpoint, because twelve inspectors, representing as many divisions, have their individual ideas regarding the values of X, 1, 2, 3, 4, and 5. The writer recalls a set of side rods marked "2" on division C, while on the K division a similarly designed set in exactly the same condition were defined as "5." There are hundreds of parallel illustrations, but the point intended to be conveyed is no doubt appreciated without further elaboration.

These reports are made up, as a rule, by the local engine inspector or roundhouse foreman, and through the heavy pressure of work devolving on each of these men, their preparation is generally neglected until the day on which they are due in the master mechanic's office to be copied and forwarded. In consequence they will, in all probability, use the last month's reports as a basis, raising the symbols here and there to indicate additional wear which thirty days' service would seem to imply. If

rods and motion work have been rated "1" they will likely be raised to "2"; and if the tire wear has been "1-32," it will be increased to "2-32," with no actual examination in either case, and notwithstanding that no appreciable wear may have ensued in any of the parts under consideration. It might be indeed that actual renewals were made since the last report which served to return the part affected to "X," but these are frequently forgotten in the rush to get the new reports out on time. It must be plainly said that such forms as a whole are simply a hodge podge of incongruities. The writer, based on his experience elsewhere, considered them as absolutely valueless in the direction of lightening his labors while engaged in the general inspection of the A. B. C. Railroad, and did not ask permission from a single master mechanic to look at one of them during his entire long trip over the line, until after the report of his own conclusions had been forwarded.

The adoption of the definitions "good," "fair" and "poor," no matter what shortcomings they may evince, were adequate in this connection, because their application was made by the same person to all of the locomotives examined. The same presumed requirements to meet ideal conditions were held steadily in mind from the first locomotive examined to the last, and in view of this uniform treatment, the conclusions were impartial and served to portray what was desired.

The following examples of the individual engine reports submitted by the inspector are literal reproductions from his files, the only change being the disguise of the engine number and class. These notes were, of course, not forwarded singly, but were held until sufficient had been accumulated to make up a letter, generally ten or fifteen. The average speed of the inspection was twelve locomotives per day, but other assignments from time to time prolonged the entire inspection to over ten months. In every instance the master mechanic interested received a carbon copy of the letter above mentioned. This was merely for his information, as the inspector had no authority to order work done or to correct abuses.

Engine 4361, class Z-12, 2-8-0. Tires 2⅝", wear 9/32". Comment: 1" end play in engine truck. Right cylinder banded at back end, but when inspected band was hanging loose. 1" end play in driving wheels, and metal is entirely off face of left main driving box. Bottom rail of left main frame broken ahead of main pedestal, and left main pedestal binder has been pieced to hold frame ahead of fracture: appears to be adequately repaired for the time being. Frame key ahead of right cylinder is working and has a dutchman. Side rod brasses generally are unfit for further service in present condition. Right No. 1 brass is broken; bolts are loose, and strap is working on the rod. Right No. 2 brass is loose in rod, and all knuckle pins pound heavily. Valve gear in wretched shape; shows over 1" on right valve stem, and ¾" on left stem. The transmission bars are much worn and nuts are loose on bolts. Both crossheads pound bad in guides. Drawbar wants shortening. Some of the pedestal binders have temporary bolts. If it is desired to continue this engine in service it should at least be thoroughly tightened up underneath, otherwise it will speedily break down. General conditions "Poor."

Engine 6852, class P-21, 4-6-2 (new engine). Tires 3", wear 2/32". Comment: Engine gathering end play very rapidly in the trailing wheels. In this instance it appears to result from excessive wear due entirely to inadequate lubrication. I have noticed generally in engines of this class that this part is dry and does not seem to receive attention. There is no provision for feeding oil to the face of the liner, and any neglect on the part of the engineer is liable to result in cutting or possibly twisting the liner off. General condition "Good."

Engine 2831, class Z-16, 2-8-0. Tires 3", wear 9/32". In general "Poor" condition (awaiting shop, and will not be used until repairs are made).

Engine 4051, class Z-17, 2-8-0. Tires 2⅛", wear 7/32". Comment: Left crosshead has ¾" lateral play in guides; bottom gib is working, and has dutchman. This requires repairs at once; it is in poor shape. Left engine truck wheel is wearing a sharp flange. Right cylinder banded. ½" to ¾" end play in driving wheels. One of the two bottom bolts is broken in back hanger of right No. 1 driving spring, and spring has "U" clamp over it encircling frame. This clamp is over spring about six inches back of band, with its other end in the fillet of the main frame where the pedestal leg joins the frame back. This wretched arrangement transmits all shock to the main frame at its recognized weakest point. It will break the frame in time. General condition "Fair."

Engine 5051, class Z-17, 2-8-0. Tires 3", no wear. In general "Good" condition. No special comment.

Engine 2261, class X-9, 4-4-2. Tires 2⅝", wear 5/32". Comment: Right main driving tire has sharp flange, and will take gauge. Left front driving tire has flange about down to gauge and will bear close watching. Guides, both sides, require closing; the inside bars are the worst. It is a fact for all engines of the A. B. C. railroad, having four bar guides that the inside bars are always in poor shape, at least embodying more crosshead pound than the outside bars. The reason is no more or less than that the inside bars are hard to get at by the persons actually engaged in closing guides; hence they are neglected. It is very bad for crossheads, with guides of this type, to allow any discrepancy between the wear of the outside and inside bars, as with any inequality in this regard it subjects the cross head to a milling motion between the tighter bars. This is supposed to explain why crossheads of this pattern are generally always rounded on the wearing surface for the outside bars. The driving box wedges are pretty well up on the engine and will require lining soon. Driving box shoes are shouldered above the boxes, and this suggests the fact that the best practise is not followed in our shops of milling the face of the shoe and wedge for about three inches down from the top, to a depth of say 1/16", although it is followed in spots. There is 1½" lateral motion in the trailing wheels by actual measurement. This condition merely converts the engine into a track-spreading device when at speed. Eccentric straps are much worn, and have heavy pound on cams. Links and transmission bars worn generally. Left main side rod bushing very loose in rod. Right main frame broken back of No. 1 pedestal, top rail. This has not been patched, and all stresses supposed to be borne by this part when in normal condition are now transmitted to other parts not designed to sustain them. General condition "Poor."

Engine 2999, class B-11, 0-6-0. Tires 2", wear 11/32". Comment: The driving tires of this engine are worn so unevenly that it becomes quite difficult to secure a measurement of approximate correctness, even with the most improved self-adjusting measuring devices. However, the 11/32" wear above mentioned applies best to the tire on right No. 1 driver. This tire is 2" thick, and is, over the grooving, as these measurements are always returned. It embodies a flange in such a condition that attention must be invited to it. It is worn sharp below the standard 1" limit gauge, and to what we commonly term a "knife edge" as descriptive of a very sharp flange. Furthermore, this flange is 1½" deep, measuring vertically from what remains of the throat of the flange. This tire is not in a fit condition for any service. The depth of grooving in the other tires is, right No. 2, 9/32"; right No. 3, 8/32"; left No. 1, 8/32"; left No. 2, 8/32", and left No. 3, 9/32". Back driving wheels have 1⅛" end play, and main wheels 1" end play. Shoes and wedges are much worn and are heavily shouldered immediately above the driving boxes. Right main driving box wedge is blocked up on a piece of wood. Flange is broken entirely off left main wedge, and left No. 1 wedge is tight against top of frame and blocked, with nearly ⅛" pound in that box between shoe and wedge faces. Both crossheads are pounding severely in guides. Driving box crown brasses worn very thin. Side rod brasses pound bad. Rockers are loose in boxes and valve motion is worn generally. Since gathering the above notes I am advised by the road foreman of engines that this engine is intended for shop in a day or so, hence this description is not continued in detail. General condition "Poor."

Each division was, of course, separately inspected and finally reported on before passing to the next, and after notes similar to the above had been returned accounting for each engine on that division's assignment, these were compiled by the inspector into a final report of the division. It merely remained to count the totals of engines defined as "Good," "Fair" and "Poor," in the reports already submitted from that territory, to form the proper recapitulation explanatory of the local situation. In this recapitulation was included the number of engines in the back shop belonging to that division. The sum of the "Good" and "Fair" engines, that is, the serviceable power, established the percentage of efficiency for each division at the time of the inspection. These final reports also included some discussion of the predominating detrimental conditions, and also a mention of the favorable features which had been noted.

Each final report was prefaced with a recapitulation as above outlined, and of which the following quotation from the "C" division may serve as an illustration:

Engines inspected, 130.	
Engines in "Good" condition,	63, or 48%
Engines in "Fair" condition,	40, or 31%
Engines in "Poor" condition,	17, or 13%
Engines in shop,	10, or 8%
Efficient engines,	103, or 79%

An analysis of the above quoted seven reproductions of the individual engine reports might infer that the description of the various parts was characterized by undue severity, particularly in connection with engines 4361, 4051, 2361 and 2999, but this was not so intended by the inspector. Conditions were so flagrant in these four instances that pardonable enthusiasm in the general cause for the moment misled the inspector from the conventional path of delineation without personal comment. Happily, however, all such of the many occasions wherein this became manifest were viewed with tolerance, not only by the

general mechanical superintendent, but by the division master mechanics as well. Indeed, it must be said that the attitude of the latter toward the inspection was most praiseworthy throughout, and to a man they appeared grateful that these things were so brought to their attention. On several divisions these reports served as an awakening to conditions which they never believed could exist; hence the inestimable value of the moral effect pertaining to the inspection, if nothing else.

The true value, however, from a mechanical standpoint of the 1526 individual reports returned, covering each engine on the A. B. C. system, was in the analysis of the most recurrent items which these notes exhibited in the aggregate. For instance, through them all must run a preponderance of something. If in the final summary five hundred times the mention was made of excessive lateral motion in driving boxes, then there must be a crying need for a remedy in this quarter; if three hundred cases were present of unduly pounding crossheads, something is radically wrong, and if the final count should exhibit one hundred broken frames in service, the mention affords food for reflection on whether the design is fundamentally weak or whether or not wrought iron is adequate for the purpose of frame construction.

If on the A. B. C. Railroad the degree of curvature is about the same for all divisions, and one particular division is indicated by the reports as having a majority of sharp or cut flanges, logically something must be amiss with the tire setting on that particular division; or, if it should be noted that on the "K" division the guide cup tops are all on, whereas on the majority of the other divisions they were found all off, then the other divisions are not adequately maintaining their oil cup tops, and thus it goes to the end of the chapter.

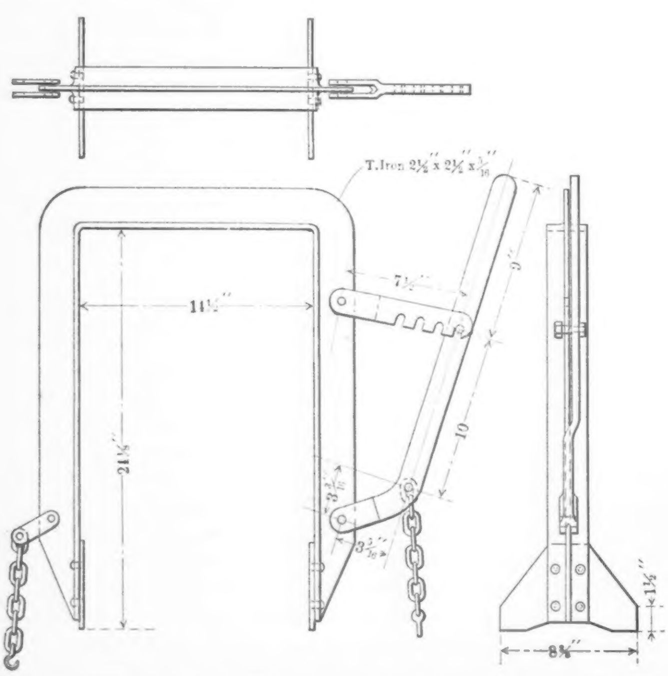
The inspection effectually developed the fact that notwithstanding the uniformity presumed to exist in the appreciation of conditions detrimental to locomotive efficiency, there is, nevertheless, a singular divergence of opinion among master mechanics in regard to the valuation to be placed on these several detrimental features. On one division it was found that the driving box wedges were maintained in a manner to absolve them from the slightest criticism, while at the same time the rod brasses and knuckle pins on these identical engines were in utter disrepute. On the very next division, however, the condition of the rods was irreproachable, but the wedges were jammed against the top of the frame, as high as they would go, with the driving boxes pounding terrifically in the jaws. One master mechanic laboriously patched everything that broke, whether frames or crossheads, but another advanced that the part never would have failed if it had not embodied a latent defect, and insisted on its renewal. It was this divergence of opinion on every hand which gradually inclined the writer to the opinion that the master mechanic is a much more subtle factor in the scheme of locomotive maintenance than is commonly suspected. The consideration of this feature served to endow the inspection with a distinctively human element certainly not anticipated by the inspector when his work was inaugurated.

There was another end in connection with this inspection which has not been alluded to, and this the inspection of the standard practices prevailing in the general shops of the A. B. C. Railroad, but the mention of this properly belongs in the succeeding article, which will treat in some detail on what the inspection actually disclosed in connection with the wear and tear of locomotives while in service, and the differences exhibited in the latter between the various divisions.

FOR THE SHOP SUPERINTENDENT AND FOREMAN.

AIR MOTOR SUPPORT ON BOILERS.

When using an air motor for drilling on boilers it is often practically impossible to securely fasten the ordinary drill post so that it can be used, if in fact it is possible to use it at all, and in the different shops throughout the country many ingenious schemes have been devised for holding the motor when doing this work.



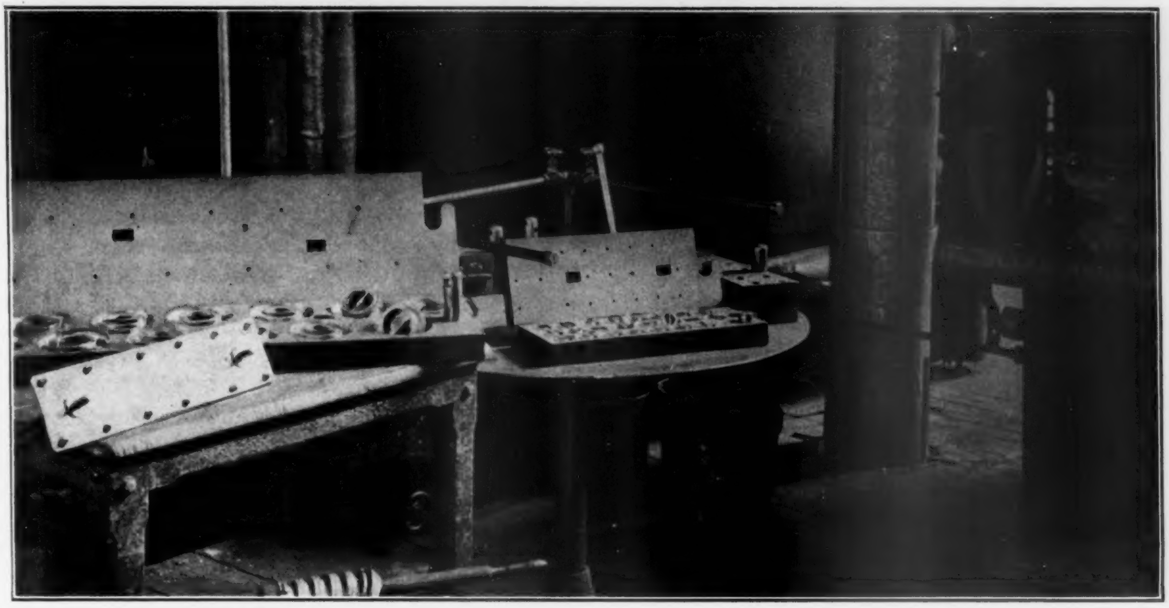
DETAILS OF AIR MOTOR SUPPORT FOR DRILLING BOILERS.

One of the handiest of these devices is shown in the illustration and is in use on the Lake Shore & Michigan Southern Railway. It is light, quickly applied and can be securely held in place. It is very easy to move to suit the proper angle at different places and it forms a very secure support.

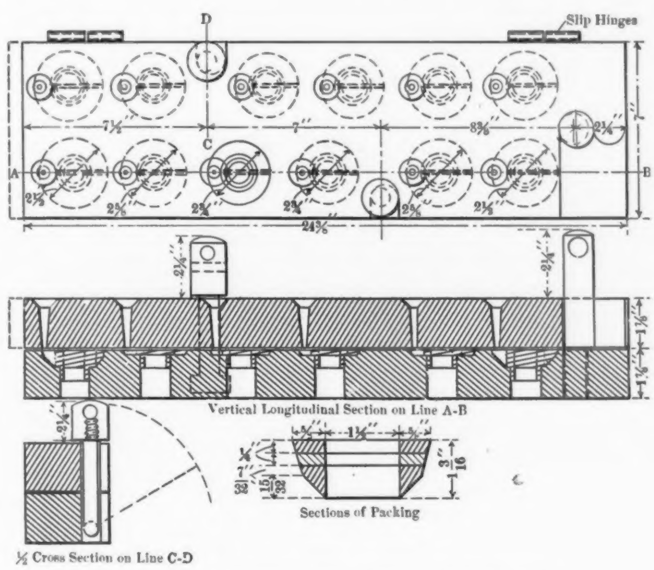
In construction it consists of a 2½ x 5/16 in. T iron bent to a U shape about 24 in. deep, and having at its extremities a plate 8⅜ in. wide, notched out in the center, to give a secure footing on a round surface. On one side of this U a short piece of chain with a hook is secured and on the opposite side is a lever to which a longer section of the chain is fastened at the proper point to give a toggle joint effect and a very strong pull as the lever is drawn into place. A latch for holding the lever when secured is provided and the whole affair can be fastened to any boiler or tank of any diameter and accurately located in a very short time.

MOULD FOR METALLIC PACKING.

Valve stem and piston rod packing which requires only to be bored to be ready for application can be cast in the moulds shown in the accompanying illustrations. These consist of two heavy slabs of cast iron, about 2 inches thick, joined together by hinges, which permit the upper plate to slide over the lower. The lower slab is drilled and finished to the proper shape for the outside of the different sections of the packing and steel rings of the proper size for forming the inner surface and having a projection for making the slit in the side, are inserted in each mould. In the top plate, which is smooth on its lower face, are the gates for pouring.

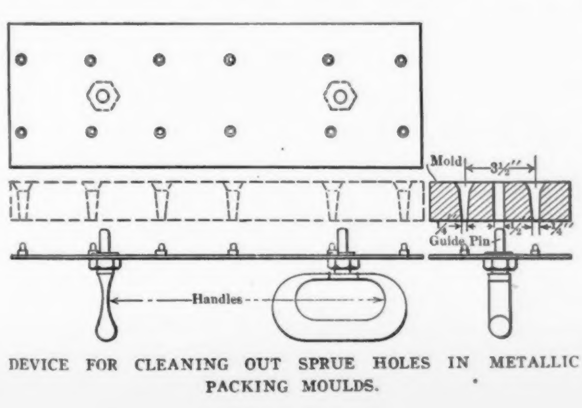


VIEW SHOWING ARRANGEMENT FOR MOULDING METALLIC PACKING, WHICH REQUIRES ONLY BORING. THE CIRCULAR TABLE REVOLVES AND THE PIPES SHOWN ABOVE IT KEEP A STREAM OF AIR PLAYING ON MOLDS. ONE OF THE PLATES FOR CLEANING SPRUE HOLES IS SHOWN ON THE TOP OF THE TABLE AT THE LEFT AND THE STICKS ON WHICH THE PACKING IS STORED AND TRANSPORTED ARE ILLUSTRATED BY THE EXAMPLE LYING UNDERNEATH THE TABLE.



DETAIL OF MOULDS FOR METALLIC PACKING.

These moulds are poured on a revolving table in sets of four and after each is filled the table is revolved so that it brings it underneath a horizontal pipe, which keeps a stream of air playing over the moulds continuously. They are kept in this circulation of air until the four moulds have been filled; then a bar is inserted through the post which is seen projecting up on the right hand side of each mould and it is given a half turn, which, because of its eccentric setting, slides the upper plate on the lower and cuts off the metal at the gates, so that the surface of the packing is perfectly smooth. The same bar is used for raising the top and the packing is removed and put upon specially shaped carriers, one of which is shown in the illustration.



DEVICE FOR CLEANING OUT SPRUE HOLES IN METALLIC PACKING MOULDS.

The metal remaining in the sprue holes is ejected by means of a special set of punches, inserted from underneath. The construction of these is also shown in the illustration.

Packing coming from these moulds is as smooth as could be desired on the outside and is periodically fitted to a master gauge to see that it is maintaining its proper shape. The three pieces forming one set, are assembled and bored to suit the size of the rod they are to be used upon, after which they are ready for application.

This photograph was taken in the Readville shops of the New York, New Haven & Hartford Railroad.

LUBRICATION AND LUBRICANTS.

Prof. Charles F. Mabery, professor of chemistry at the Case School of Applied Science, presented a paper on the above subject at the January meeting of the American Society of Mechanical Engineers in New York City. His conclusions, based on a series of tests at Case School, are as follows:

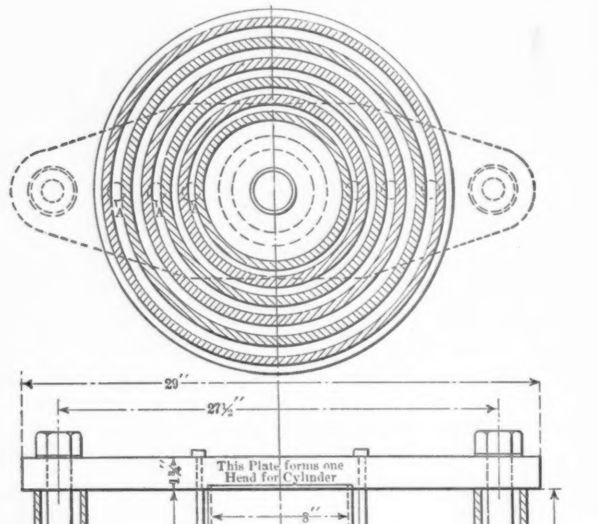
"The results with reference to the uses of graphite as a solid lubricant indicate that in the deflocculated form it can be applied with advantage in all kinds of mechanical work. One of its most characteristic effects is that of a surface evener by forming a veneer equalizing the metallic depressions and projections on the surfaces of journal and bearing, and, endowed with a certain freedom of motion under pressure, it affords the most perfect lubrication. In automobile lubrication the great efficiency of graphite in increasing engine power, in controlling temperatures, and wear and tear of bearings, has been brought out in a series of tests conducted by the Automobile Club of America. In connection with the reduction in friction of lubricating oils by graphite the extremely small proportion necessary is worthy of note; the proportion used in this work is equivalent to one cubic inch of graphite in three gallons of oil. The curve of temperature for Aquadag, showing only slight increase above that of the surrounding atmosphere, demonstrates an important economic quality of controlling temperatures in factory lubrication, and thereby avoiding the danger of highly heated bearings, which are frequently the cause of fires.

"In the observations described in this paper, and, in fact, in

all the work that has been done in this field, there is not a more impressive example of the efficiency of graphite in lubrication than that presented in the curves of friction and temperature of water and graphite, for with water, serving merely as a vehicle and completely devoid of lubricating quality, the graphite is permitted to perform its work without aid and with no limiting conditions."

FORMING BRAKE CYLINDER PACKING.

The difficulty of inserting a new leather packing in a brake cylinder is well known and for the purpose of facilitating this work at the Readville shops a special press with suitable forms for crimping the edge of packing for different sized



DETAILS OF PNEUMATIC PRESS FOR FORMING BRAKE CYLINDER PACKING.

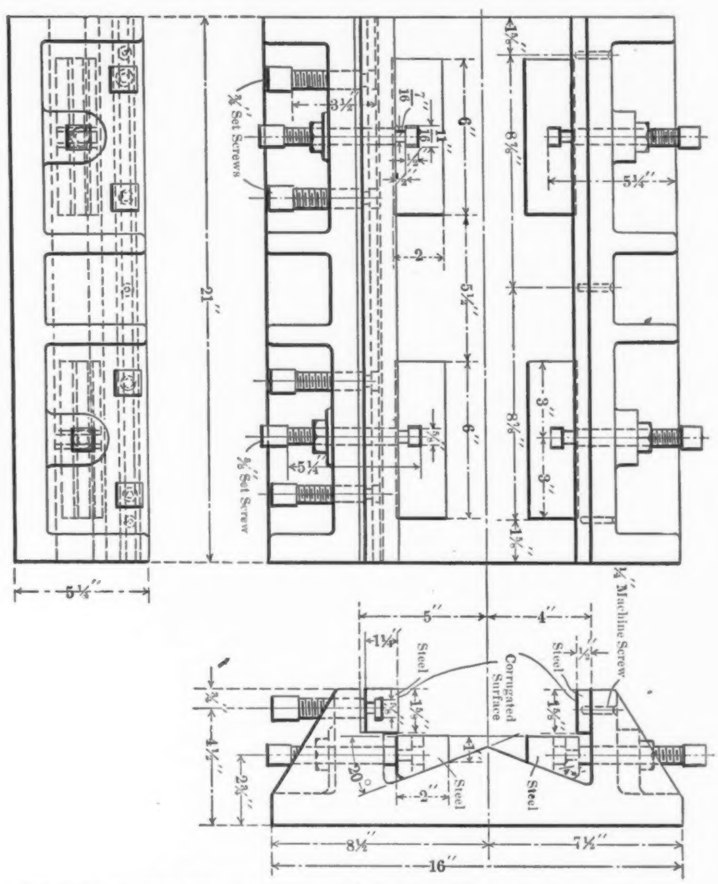
cylinders has been designed. This, as will be seen by reference to the illustration, consists simply of an ordinary 8-inch brake cylinder secured to a suitable frame and a series of rings and plates that can be fitted to the base below it.

In operation the proper sized ring is set into place and a light turn locks it. A plate that fits closely inside of it is placed over the center pin above the spring, the leather packing is then laid on this, and above it another plate, with specially shaped beads on the edges and a diameter equal to the difference between the lower plate and a double thickness of the leather, is placed. Air then being admitted to the cylinder, the plates are forced down into the ring and the leather is crimped smoothly and so evenly that it can be easily applied to the cylinder. Upon release the spring around the center pin forces the plates and packing out of the ring.

CHUCK FOR PLANING SHOES AND WEDGES.

For various reasons it often happens that the face and back edges of shoes or wedges are not in line, which necessitates accurate setting for the final planing of the face after it has been laid off on the locomotive.

At the West Albany shops of the New York Central a chuck has been designed by which this setting on the planer or shaper



DETAILS OF JIG FOR PLANING SHOES AND WEDGES, WEST ALBANY SHOPS.

can be quickly and accurately done. It consists of a bed plate with screw clamps for holding the shoe or wedge in place and four wedge shaped blocks, one near either corner on which they rest. These blocks slide on inclined faces, and are raised and lowered any desired amount by being forced inward and outward through the medium of screws projecting out through the side of the lower casting. It is easily seen that irregularity of the lower face can be quickly adjusted in this manner. Having obtained the proper surface, the piece is securely clamped by tightening up on the four set screws on one side.

"The Weathering of Coal," by S. W. Parr and W. F. Wheeler, is being issued by the Engineering Experiment Station of the University of Illinois as Bulletin No. 38. This bulletin embodies the results of weathering tests conducted on car-load lots of coal for a period of one year, in the course of which coal from various mines was exposed in covered bins, open bins and under water. The results are presented in the form of charts which show graphically the losses in heating value resulting from each condition of exposure. Copies may be obtained graits.

THE ELECTRIC SYSTEM OF THE GREAT NORTHERN RAILWAY COMPANY AT CASCADE TUNNEL.*

CARY T. HUTCHINSON.

The first three-phase installation on a trunk line railway in the United States was put into operation early in July, 1909, at the Cascade Mountain tunnel on the Great Northern Railway, in the State of Washington, about one hundred miles east of Seattle.

In general the plant comprises a hydroelectric generating station, operating under a head of 180 ft., having a capacity of approximately 5,000 kw. in generators at 6,600 volts and 25 cycles; a transmission system operating at 33,000 volts, delivering energy to a sub-station where it is transformed to 6,000 volts, at which pressure it is supplied to the overhead conductors and to the locomotive by way of an overhead trolley; on the locomotive the pressure is reduced by three-phase transformers to 500 volts for the supply of the four three-phase motors with which each locomotive is equipped.

The Great Northern Railway crosses the Cascade Mountains through a tunnel 13,873 ft. long; this tunnel is on a tangent and has a uniform gradient of 1.7 per cent., rising to the tunnel from Leavenworth, on the east; the ruling grade is 2.2 per cent., and 21 per cent. of the total distance of 32.4 miles from Leavenworth to the tunnel is on the ruling grade. From Skykomish on the west to the summit the ruling grade is 2.2 per cent. and 44 per cent. of the distance of 24.8 miles is on the ruling grade.

The operation of the tunnel with steam locomotives was at all times difficult and frequently very dangerous on account of the heat and smoke from the locomotives. Crows Nest coal, which is exceptionally free from sulphur and gas-forming materials, was used for the tunnel service. It was the custom to clean the fires of each locomotive and to put on just sufficient coal to carry it through the tunnel. In the tunnel the rails became very wet from condensed steam, and were frequently covered with a layer of coal soot and ground sand, making them very slippery. The temperature in the locomotive cab was almost unbearable, rising at times as high as 200 deg. Fahr. Under ordinary circumstances it required from twenty minutes to an hour for the tunnel to clear itself of gases, but on days when the wind was changeable, the passage of the gases from the tunnel would be stopped by the change in the direction of the wind, and they would pocket. Under such circumstances, work in the tunnel was very dangerous. There are refuge chambers containing telephones every quarter of a mile, but it was a difficult matter to keep these instruments in order, on account of the gases, smoke, and moisture.

The tunnel is lined with concrete throughout its length, and is in good condition. The roof is practically dry. The entire tunnel drips more or less from condensed steam just after the passage of a train, but is comparatively dry at other times. The temperature changes at the top of the tunnel are very rapid, varying from atmospheric temperature to several hundred degrees Fahr. from the heat of the locomotive exhaust. For these reasons this tunnel is the limiting feature to the capacity of the Great Northern Railway for hauling freight across the mountains.

Mallet compound engines are used on this division, one at the head of the train, and one pushing. The mountain section as a whole also fixes a limit to the capacity of the road, on account of the slow speed necessitated by heavy traffic; it is impossible for steam locomotives to haul heavy trains on the mountain at a greater speed than seven or eight miles per hour.

The plant described is designed for use over the entire mountain division, by extending the system of conductors and building additional stations; it was not designed for the operation of the tunnel alone, although even if the problem had been the handling of the traffic through this tunnel and its approaches only, the three-phase system would in all probability have been selected, on account of its greater simplicity and less cost.

* Abstract from the Proceedings of the American Institute of Electrical Engineers, Volume XXVIII, Number 11, November, 1909.

The original problem was to provide equipment to handle a train having a total weight of 2,000 tons, excluding the electric locomotives, over the mountain division from Leavenworth to Skykomish, a distance of 57 miles. The system was to be first tried out at the Cascade Tunnel.

The tractive effort required to accelerate a train having a total weight of 2,500 tons on a 2.2 per cent. grade, using 6 lb. to the ton for train resistance and 10 lb. to the ton for acceleration, making a total of 60 lb. to the ton, is 150,000 lb.; this would require four locomotives of a tractive effort of 37,500 lb. each. The railway company's engineers limited the weight on a driving axle to 50,000 lb.; therefore four driving axles per locomotive are needed, giving a coefficient of adhesion of about 19 per cent. This is a measure of the maximum power required. The locomotive was, therefore, designed to give a continuous tractive effort of approximately 25,000 lb., and it was expected that four would be used with a train of maximum weight. But the locomotive as built greatly exceeds this specification.

The General Design of Locomotive

The principal data of locomotive are as follows: total weight 230,000 lb. all on drivers; two trucks connected by a coupling, each truck having two driving axles; a three-phase motor connected by twin gears to each axle; gear ratio, 4.26; diameter of driving wheels 60 in.; synchronous speed of motor 375 rev. per min., giving a speed of 15.7 miles per hour at no load, dropping to 15 miles per hour for a load corresponding to the one-hour rating. The motors are wound for 500 volts and are completely enclosed and air-cooled; clearance between stator and rotor, ⅛ in.; trolley pressure, 6,000 volts; each locomotive has two three-phase transformers reducing the pressure from 6,000 to 500 volts, arranged with taps so that 625 volts may be used on the motor.

The distribution of the total weight of the locomotive is as follows:

2 Trucks	81,599 lb.
1 Cab	30,000 "
4 Motors	48,800 "
8 Gears and gear cases	11,000 "
2 Transformers	20,800 "
2 Air compressors	5,800 "
1 Blower	1,300 "
40 Rheostats	10,200 "
56 Contactors	3,200 "
Miscellaneous	17,400 "
Total	230,000 lb.
That is,	
Total weight per axle	57,500 "
Dead weight per axle	18,500 "

The locomotive will give 37,400 lb. tractive effort in continuous duty, or 47,600 lb. tractive effort for one hour.

Calculations from the profile of this section give:

Westbound, Leavenworth-Cascade	
Average up-grade	1.37 per cent.
Distance	32.4 miles
Work per ton at the wheel rim	2.15 kw.-hr.
Average power per ton at the wheel at 15 miles per hr.	1.00 kw.
Eastbound, Skyomish-Cascade	
Average up-grade	1.88 per cent.
Distance	24.8 miles
Work per ton at wheel rim	2.16 kw.-hr.
Average power for round trip per ton at wheel rim at 15 miles per hour	1.31 kw.
Average power per ton at wheel at 15 miles per hour for entire division	1.12 kw.
Maximum power per ton accelerating on 2.2 per cent. grade	1.8 kw.

These figures assume the train to be moving continuously and are based on 6 lb. per ton train resistance on the level, as are all calculations herein unless otherwise stated.

The average power of the locomotive when pulling will then be 1.12 kw. per ton, and therefore each motor can carry 250 tons in continuous service on this mountain division, assuming there are no stops and no opportunity for cooling; or each locomotive could haul $(4 \times 250 - 115) = 885$ tons trailing load, if the power requirements were continuous; as there are necessarily stops, the rating as determined by heating is somewhat greater than this.

The locomotive has been tested to a maximum tractive effort of nearly 80,000 lb., corresponding to a coefficient of adhesion of nearly 35 per cent.; with 60,000 lb., or 26 per cent., each locomotive can accelerate the train of 885 tons trailing on a 2.2 per cent. grade, using 60 lb. per ton as the total tractive effort; or,

in other words, the train that a locomotive can haul, as determined by the average duty and safe heating limits, is just about equal to the train that it can accelerate on the maximum grade; that is, the average capacity of the locomotive and its maximum capacity are in the same proportion as the average duty and maximum duty. The design is well balanced.

Making some alowance for these figures for the sake of conservatism, the rating of the locomotive on this division can be put at 750 tons trailing load.

Mechanical Design of Locomotive

The locomotive is of the articulated or hinged type, having four driving wheels on each half of the running gear and is without guiding wheels. The running gear is not two independent trucks coupled together, but is more nearly comparable to the Mallet type of steam locomotive, in that the hinged sections are so rigidly connected that they tend to support each other vertically and guide each other in taking the curves, although the hinges are designed to offer minimum resistance to lateral flexure. There are no springs to prevent this flexure, and the wheel base is free to accommodate itself to any curvature; the effect of this guiding action is to minimize the flange wear, as in the Mallet locomotive.

Operation of the System

The electric service was started on July 10, although one or two trains had been handled previously. From that time to August 11, practically the entire eastbound service of the company has been handled by electric locomotives. During this period of 33 days there have been 212 train movements, of which 82 were freight, 98 passenger, and 32 special. In each case the steam locomotive was hauled through with the train. The tonnage handled was as follows:

Freight tonnage	171,000 tons.
Passenger "	88,500 "
Special "	15,500 "
Total	275,000 tons.

This is an average of 8,350 tons per day, all eastbound.

The average freight train weight has been as follows:

Cars	1,480 tons.
One Mallet locomotive	250 "
Three electric locomotives	345 "
Total train weight	2,075 tons.

The maximum weight of cars was 1,600 tons; the minimum 1,200 tons.

The representative passenger train handled is made up as follows:

Coaches	426 tons.
One steam locomotive	250 "
Two electric locomotives	230 "
Total train weight	906 tons.

The maximum was about 125 tons greater.

Frictional resistance of steam locomotives.—The power required to haul these trains seemed greater than it should be; investigation showed that the difference was accounted for by the unexpectedly high frictional resistance of the steam locomotives, as a trailing load; tests were made on several engines with the following results:

TABLE III.

1 Test No.	2 Engine classification		3 Total weight with tender Tons	4 Weight on drivers Tons	5 Total resistance on 1·7 per cent grade lb.	6 Equivalent weight of freight cars Tons
1	Mallet No. 1904	2-6-6-2	250	158	19,340	482
2	" No. 1911	2-6-6-2	250	158	17,500	432
3	" No. 1905	2-6-6-2	250	158	24,200	602
4	Consolidation	2-8-0	159	90	10,080	255
5	Pacific	4-6-0	188	70	10,270	257

The tests were made by towing an engine through the tunnel behind an electric; the electric was fitted up with test instruments and the total tractive effort was thereby obtained. An allowance of 6 lb. per ton was made for the resistance of the electric and the difference is the draw-bar pull in column 5. Column 6 is the equivalent load in cars, taking car resistance as 6 lb. per ton. Each test given is the average from six to twelve separate readings. The average for the three Mallets is more than 20,000 lb.

If the grade resistance be deducted from the total pull, and the difference lumped as "lb. per ton" for the locomotive and tender, there results:

TABLE IV.

1 Engine classification	2 Frictional resistance of locomotive	3 lb. per ton
Mallet No. 1904	10,840 lb.	43.0
Mallet No. 1911	9,000 "	36.0
Mallet No. 1905	15,700 "	63.0
Consolidation	5,480 "	34.5
Pacific	3,870 "	20.7
Electric	1,500 "	13.0

The average for the three Mallets is 47.0 lb. per ton for the frictional resistance on a straight level track.

The figure for the electric was obtained from tests made by towing it by a motor car on straight level track; this test was made at Schenectady. Included in it is the resistance of gears and bearings of motors.

Using 20,000 lb. as the pull required for a Mallet on the 1.7 per cent. grade, the approximate average from Table III, the total tractive effort for the average freight train, is:

Cars	1,480 tons × 40 = 59,200 lb.
One Mallet	250 tons × 80 = 20,000 "
Three electrics	345 tons × 40 = 13,800 "
Total tractive effort	93,000 lb.

This is equal to 31,000 lb. for each electric locomotive.

On account of the very high frictional resistance of the Mallet engine as a towing load, this representative train is equivalent to 1,980 tons, excluding the three electric locomotives, or a total of 2,325 tons, on the 1.7 per cent. grade. This is on the assumption that the draw-bar pull required for the Mallet is replaced by freight cars at 6 lb. to the ton; this represents the average freight train handled.

The tractive effort for the passenger trains varies from 40,000 to 50,000 lb., depending on the number of steam locomotives taken through; two electrics are ordinarily used, although one would answer in nearly all cases.

During this period there have been no delays due to failure of the electric locomotives, and but two trifling delays due to failures of the electric plant, both chargeable to the transmission line and both caused by accidents beyond the control of the operating force.

On August 11 the electric service was discontinued, owing to failure of both water wheels. Service was resumed on September 9 and has been continued regularly since. The plant was taken over by the operating department of the railroad late in September.

The westbound service was not at first handled by the electrics regularly, as there is nothing in particular gained by breaking the trains electrically on this short stretch, but now westbound passenger trains are so handled, for the benefit of the passengers.

Regenerating.—A number of tests have been made to determine the power returned when regenerating; the following is typical:

TABLE V.

TRAIN: MALLET ENGINE, 1,550 TONS CAR WEIGHT, TWO ELECTRICS ON 1.7 PER CENT. GRADE.

Force due to grade		Frictional Resistance	Remainder for acceleration
Mallet	8,500 lb.	11,500 lb.	− 3,000 lb.
1550 tons in cars	52,500 "	9,300 "	+43.200 "
Three electrics	11,700 "	2,070 "	9,630 "
Total for acceleration			49,830 "

This is equivalent to 1,495 kw. delivered to the gears of the motors at 15 miles per hour.

The efficiency of the locomotive is approximately 80 per cent. —hence the power returned to the line, should be 1,200 kw.

The test of this train gave 950 kw.; this difference is due to the standard practice, not yet abandoned, of keeping a certain number of car pressure retainers set on down grade. The Mallet, instead of adding to the delivered power, is an additional load that has to be carried by the train.

A similar test on a ten-car passenger train weighing 950 tons gave:

Delivered power, calculated	590 kw.
" " measured	597 "

In this case there was no added resistance of pressure retainers. These tests merely confirm the calculations, as they should. On a 1.7 per cent. grade, then, one ton, descending at 15 miles per hr., will deliver 0.67 kw. to the system; on a 2.2 per cent. grade it will deliver 0.91 kw.

Efficiency.—The losses in the system when delivering 4,000 kw. to the locomotive, at the west end of the Wellington yard, are:

Place.	Power. Kilowatts.	Per cent.
Power house low tension bus-bars	4,740	100
Sub-station " " "	4,250	89.8
Trolley wheel of the locomotive	4,000	84.5
Driving axles " " "	3,320	70

The average efficiency is somewhat higher than 70 per cent.

Handling of Trains

Economy of Mallets.—It is interesting to compare the performance of a Mallet compound locomotive under the same operating conditions as this system. The data for this are given by Mr. Emerson, superintendent of motive power of the Great Northern Railway Company, in a discussion before the American Society of Mechanical Engineers on locomotives of this type; as an excellent performance he gives these data:

Recent performance shows that on a round trip over this division the L-1 engines handled 1,600 tons with a total of 43 5/6 tons of coal, or equivalent to 25.13 lb. of coal per 100 ton-mile.

The division referred to is from Leavenworth to Everett, 108.7 miles. The work done per ton for a round trip over this run is readily calculated; from the profile I find,

Total rise, westbound	2,212 ft.
" " eastbound	3,440 "
	5,652 ft.

and $5{,}562 \times 2{,}000/2.65 \times 10^6 = 4.26$ kw.-hr., at the rail; this is the work done per ton in lifting the train; the work done against train resistance, assuming resistance to be 6 lb. per ton, for 108.7 miles, is 1.3 kw.-hr.; the total work done in round trip per ton 5.56 kw.-hr. There should be a negligible addition to this for starting the train.

The average train weight is:

Cars	1,600 tons.
One engine, 109 miles	
Second " 58 "	
Equivalent engine weight	380 "
Total	1,980 tons.

The coal used was 43 5/6 tons, equal to 87,660 lb.

Coal per ton	44.3 lb.
Coal per kilowatt-hour	8.0 "

A modern steam station can deliver one kilowatt-hour for 3 lb. of coal, at the bus-bar, which, with an efficiency of 70 per cent. to the rail, gives a consumption of 4.28 lb. per kilowatt-hour at the rail; in other words, the Mallet compound requires nearly twice as much coal per kilowatt-hour at the rail as would be used in a modern steam station in the place of the hydroelectric station at Leavenworth.

Advantages of 3-Phase System

This plant has demonstrated, in my opinion, that the three-phase induction motor has certain very marked advantages over any other form of motor for heavy traction on mountain grades; these advantages may be stated somewhat approximately.

Maximum electrical and mechanical simplicity.—This point is of great importance and was one of the principal reasons for using the three-phase system; the motors will stand any amount of abuse and rough use.

Greater continuous output within a given space than can be obtained from any other form of motor.—This, I believe, is shown by comparison with other electric locomotives; it is due to the fact that the losses can be kept lower in a three-phase motor than in any other type.

Uniform torque.—This is important, particularly at starting. I believe that a three-phase motor will work to a three or four per cent. greater coefficient of adhesion than a single-phase motor at 15 cycles.

The possibility of using 25 cycles.—This is important, as it leads to a less cost and a better performance of power station apparatus; moreover, it is standard and the power supply can readily be used for other purposes, as well as for traction; a commercial supply can be provided.

Constant speed.—This is ordinarily stated as a disadvantage of the three-phase motor; but in my opinion it is a distinct advantage in mountain service, particularly the limitation of the speed on down grades. It has also the advantage on up grades that meeting points can be arranged with greater definiteness. There is a general notion that the impossibility of making up lost time with the three-phase motor will be a decided drawback to its use. This would be true if there were the same liability to lose time with three-phase motors; but when a train can be counted on to make a definite speed, without regard to conditions of tracks or of its load, there is less liability to lose time. Although I am not prepared to state that a three-phase motor is suitable for cases where the profile is very variable, yet it is by no means certain that it would not work out well; the question is merely one of making a given schedule between two points with greatest regularity.

Regeneration on down grades.—This matter has been discussed since the earliest days of electric traction, but, as far as I know, has not been, up to the present, put into practice. Although this result can be attained with other forms of motors, yet it is most perfectly attained by three-phase motors, there being no complications involved. This is of importance in reducing the power-house capacity required for a given service; although, no doubt, the saving in power-house capacity will not be as great as indicated by theory, owing to the various emergencies that must be provided for, nevertheless there will be a material saving. A 2,500-ton train on the average down grade of 1.5 per cent. will deliver about 1,400 kw. to the system. The equivalent power house capacity would cost at least $200,000; hence if only 20 per cent. of this can be utilized the saving will equal the cost of one locomotive.

Excessive short-circuit current is impossible and consequently destructive torque on the gears and driving rigging is eliminated. There will be no necessity for the complication of a friction connection between the armature and driving wheels, as in the design of recent large direct-current electric locomotives.

Impossibility of excessive speeds.—Even when the wheel slips the speed remains constant. Therefore, the maximum stresses put on the motor are less and are more accurately known than with any other form of motor.

Disadvantages of Three-Phase

On the other hand, the principal disadvantages of three-phase motor, for traction use, are commonly stated to be:

The constant speed.—This is rather an advantage for this class of service.

Constant power.—The fact that the motor is a constant-power motor and therefore requires the same power at starting and while accelerating as at full speed. While this is true, it is not a matter of any particular consequence in a service where the stops are very few, and consequently the proportion of total time spent in acceleration is small, and where the additional power required to accelerate the train is a small percentage of the power used by the train at full speed. In this particular case on the 2.2 per cent. grade, when accelerating at the rate of 10 lb. to the ton, the power required during acceleration is only 20 per cent. greater than that required at full speed; this is not a serious matter.

Small mechanical clearance.—In this particular motor the clearance is ⅛ in., which is ample for all practical purposes.

Inequality of load on several motors of a locomotive due to differences in diameter of driving wheels. To meet this an adjustable resistance is included in the rotor of each motor, the motors are then balanced up and no further attention is required

as long as the wear on the driving wheels is approximately the same. If, at any time, the load becomes badly unbalanced it is a simple matter to readjust the resistances.

Low power-factor of the system.—This does not seem to be borne out by the practice. The power-factor, as shown by the switchboard instruments in the power house, is 85 per cent. This is a good result and is much higher than a power-factor of a well-known single-phase system that I recently had occasion to visit.

Two overhead wires.—There is no doubt that two wires will cause more trouble than one, and in case of complicated yard structure it might not be practicable to use two overhead wires, but where the problem is that of a single track with an occasional turn-out or crossing there is, practically speaking, no more difficulty in maintaining two wires than one.

In brief, in service of this character, the three-phase motor has marked advantages in capacity, reliability, simplicity, and general trustworthiness, when compared with any other motor.

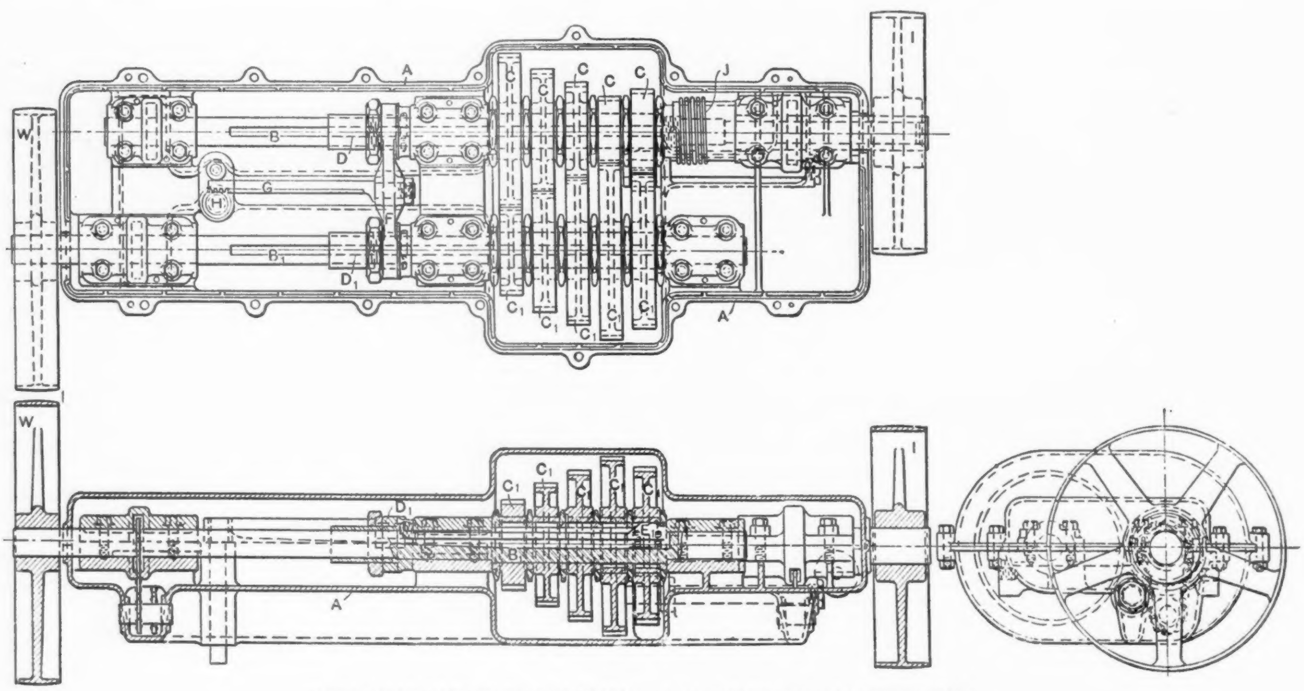
Some Minor Advantages of Electric Traction.

In the many discussions of electric traction which have recently taken place, I do not find several minor advantages sufficiently emphasized. One of these advantages lies in the fact that with electric traction the exact performance and condition of the locomotives and of all elements of the system is accurately known at each moment; on the other hand, with steam locomotives neither the engineer nor the motive power man can have any clear knowledge of the conditions of operation at the moment; he can only ascertain the performance of the locomotive by elaborate tests, which, as a matter of fact, are seldom made. The ratings and performance of steam locomotives are made up largely of "authority" based on a few tests from time to time, and take no cognizance of the actual condition of the locomotives. The importance of this, I think, is clearly brought out by the tests of the steam locomotive cited herein.

With electric locomotives the operation on a heavy grade becomes as simple as on the level; the engineers and train men feel much greater confidence in the electric locomotives and consequently the mountain division ceases to be a terror to them.

Electric traction will permit the use of very long tunnels, which are not now possible on account of difficulty of ventilation. There is no particular reason why tunnels of ten or twelve miles should not be operated as easily as those of one mile.

The great increase possible in the speed of trains with electric traction and the consequent increase in the capacity of a single track will operate to postpone for a long time the necessity for double tracking. This double tracking on a mountain is a very expensive piece of business and this saving alone will, in some cases, more than offset the cost of electrical equipment.



DETAILS OF PARKER TRANSMISSION AS ARRANGED FOR MACHINE TOOLS.

PARKER SPEED CHANGING DEVICE.

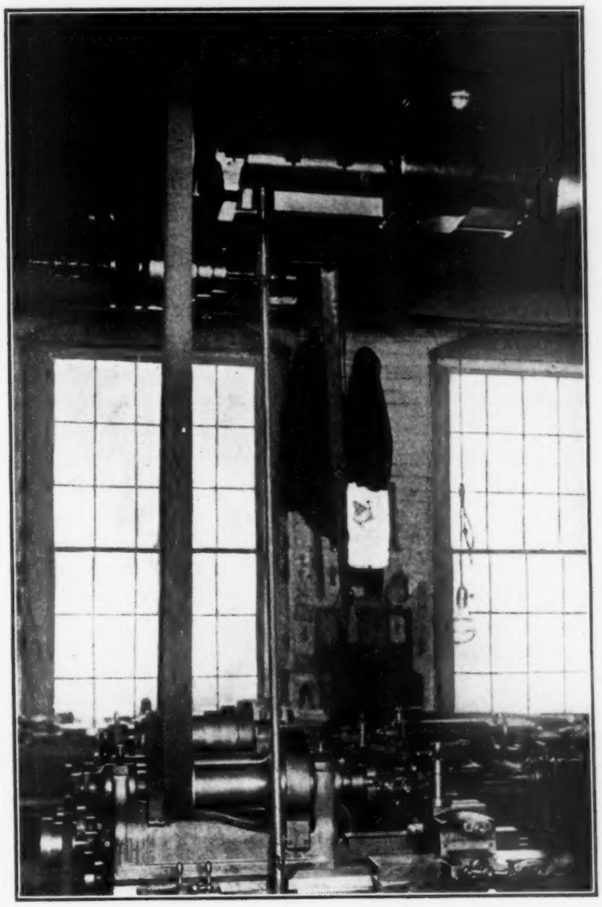
A transmission and speed changing device of the all-geared type, manufactured by the Parker Transmission & Appliance Co., Springfield, Mass., is shown in the accompanying illustrations. This is suited for use on all kinds and sizes of machines that require changes of speed and is particularly applicable to machine tools and automobiles. It gives an absolutely positive drive and can be operated either in a progressive or selective manner. It is of the non-sliding gear arrangement and can be made for any required number of speed changes at any ratio, with any combination of forward and reverse speeds. In the photograph it is shown as applied to a 16 inch Reed engine lathe, in which case the head cone has been removed and a single pulley drive applied. The transmission in this case takes the place of the counter shaft. It can, however, be made as an integral part of the machine, or located upon the floor, if desired.

Two cones of gears in constant mesh and mounted idly on parallel shafts form the principle part of the transmission; a shock absorber, applied at the driving end, is, however, a very important factor. The line drawing shows the arrangement and construction of the whole gear and, referring to it, the five gears C_1, four for forward speeds and one for reverse, are mounted idly on B_1. Meshing with these are five similar gears mounted idly on shaft B. The reversing is obtained by the use of an intermediate gear, as indicated in the end view.

A sliding key E mounted in a slot in the shafts is fitted with springs, so that it will engage in the key-way of any particular set of gears and put them into operation, all others being run idle. Between each of the gears is a collar fastened tightly to the shaft, which acts as a device for releasing the key as it changes from one gear to the other. The upper corners of the key are beveled for this purpose.

These sliding keys are secured to collars D, which slide upon the shafts and are operated simultaneously by yoke F, attached to rack G. The rack is moved by gear H mounted in the end of the vertical rod reaching up from the machine, as is shown in the photograph.

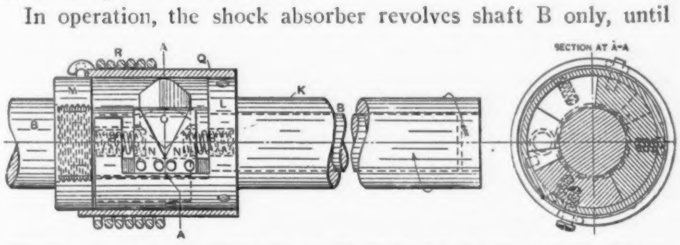
Power is transmitted to the device through pulley I, which delivers it through the shock absorber J to the cones of gears. This shock absorber is shown in detail and prevents any undue wear or breakage of the transmission from a sudden engagement of the gears. Its construction is as follows: The sleeve K is enlarged at L, at which place it is partly cut away. A piece M similar to L is fastened to shaft B. The pieces L and M overlap each other in a clutch-like manner and in the box-like space between them are two wedged-shaped blocks N and a V-shaped



PARKER TRANSMISSION FITTED IN PLACE OF THE COUNTERSHAFT OF AN ENGINE LATHE.

block O. The blocks N are forced together by the springs P, and the power is transmitted by block O being wedged in between blocks N. This mechanism is covered by the shell Q that is fastened to the sleeve head L. The helical spring R is at the proper tension to carry the idle load, one end of this spring being fastened to shell Q, and the other end to M. As the springs P force the blocks N together, these in turn hold the block O against its seat in M.

In operation, the shock absorber revolves shaft B only, until



DETAILS OF SPRING COUPLING IN DRIVING SHAFT OF PARKER TRANSMISSION.

the key in this shaft enters the slot in one of the gears, C, into which it is forced by small springs. Now a single pair of gears is revolved until the slot in the meshing gear C_1 comes opposite key E_1, at which time the key is forced into position in C_1, and now, when both keys are engaged, the working load is transferred to spring R which, not being strong enough to take the whole load, shifts it onto the blocks N and O, the block O forcing the blocks N apart until springs P offer resistance enough to permit the carrying of the load. The mechanism is thus engaged without shock or blow.

The shaft reaching down from the transmission is operated by a handle on the lathe carriage, a pointer and scale being provided to indicate which pair of gears is engaged. It can, however, be readily operated by the ordinary shifting handle, if desired.

Two years' constant service on the lathe shown have not developed any necessity for repairs or adjustment. It has also been applied to a 6-cylinder, 40 h.p., automobile and traveled over 16,000 miles without any necessity for repairs.

TREATED TIES.

The rapid progress of wood preservation in the United States during recent years is disclosed in the rapidly increasing percentages of treated ties in the total annual purchases. In 1908, 23,776,060 ties were reported by the steam and electric roads as having been treated by them or purchased already treated, which was 21.1 per cent. of all of the ties purchased in that year. The corresponding percentages in 1907 and in 1906 were 12.9 and 11.5, respectively. Twelve large railroad companies are now running treating plants of their own, and a number of roads which do not maintain such plants either buy treated ties or have their ties treated after purchase. Altogether, there were in operation in the United States in 1908 about 70 wood preserving plants.

In 1908 the steam roads treated 12,590,643 ties and purchased 10,565,925 treated ties, the total for these roads being 23,156,568 treated ties, or 21.8 per cent. of the total number of ties purchased by them, and 97.4 per cent. of the treated ties reported for that year. The use of treated ties is less general among the electric than among the steam roads. The electric roads treated after purchase 212,356 ties, and purchased in treated form 407,136 ties, making a total of 619,492 treated ties, or 9.6 per cent. of the total number purchased by them.—*From Bulletin No. 109 on Forest Products of the U. S. for 1908, issued by the Dept. of Commerce and Labor.*

RAILWAY STOREKEEPERS' ASSOCIATION.—The seventh annual convention of this association will be held at Planters' Hotel, St. Louis, May 16, 17 and 18, 1910. The following subjects will be discussed: "By What Unit of Measure is the Efficiency of a Storekeeper Properly Determined" "Economy in Mechanical Contrivances for Handling Material," "Economy of the Piece Work System in the Handling of Supplies." Committee reports will also be received on "Recommended Practices" and "Classification of Material." Secretary, J. P. Murphy, Box C, Collinwood, Ohio.

THE FLAMING ARC LAMP.—The flaming arc lamp, using the so-called yellow carbons, after several years use principally as an advertising light, is now being used to a considerable extent for the lighting of foundries, machine shops, etc., where the rooms are high, and where it is desirable to hang lamps above the crane. The characteristic distribution of this lamp as now built is particularly adapted to high buildings since the maximum light is thrown directly downward. The light is very powerful, and suited for lighting large areas when hung high. When placed too low the light would be glaring and inefficiently distributed.—*G. H. Stickney on "Illumination for Industrial Plants" in Proceedings of the Am. Inst. of Electrical Engineers.*

LUBRICATING OIL CONSUMPTION BY THE RAILROADS.—The "Report of the Commissioner of Corporations on the Petroleum Industry," in the issue of August 5, 1907, stated that 94 railroads paid out the enormous sum of \$4,068,557 for lubricants during the period of one year, in or about 1905, and that the Pennsylvania System alone spent \$385,933 for a similar purpose during a like interval.—*A. D. Smith before the Railway Club of Pittsburgh.*

POWERFUL FREIGHT AND PASSENGER LOCOMOTIVES FOR A NARROW GAUGE RAILWAY.

GENERAL DESCRIPTION OF A MALLET COMPOUND 2-6-6-2 TYPE AND A PACIFIC TYPE LOCOMOTIVE RECENTLY CONSTRUCTED FOR THE CENTRAL SOUTH AFRICAN RAILWAYS BY THE AMERICAN LOCOMOTIVE COMPANY. THIS RAILWAY HAS A 3 FT. 6 IN. GAUGE AND THESE LOCOMOTIVES ARE AMONG THE MOST POWERFUL EVER PUT INTO SERVICE ON A NARROW GAUGE ROAD.

About a year ago the American Locomotive Company built a 2-6-6-0 type locomotive 3 ft. 6 in. gauge for the Natal Government Railways of South Africa. This engine has been in service for several months and has fully met the expectations of the owners and proved most efficient and successful under the conditions existing on that road. On a 3.3 per cent. grade it easily handles 325 long tons, which is fifty per cent. more than the heaviest engines of other types can haul. It passes through 19.5 deg. curves with less flange friction than do eight coupled locomotives with rigid wheel base.

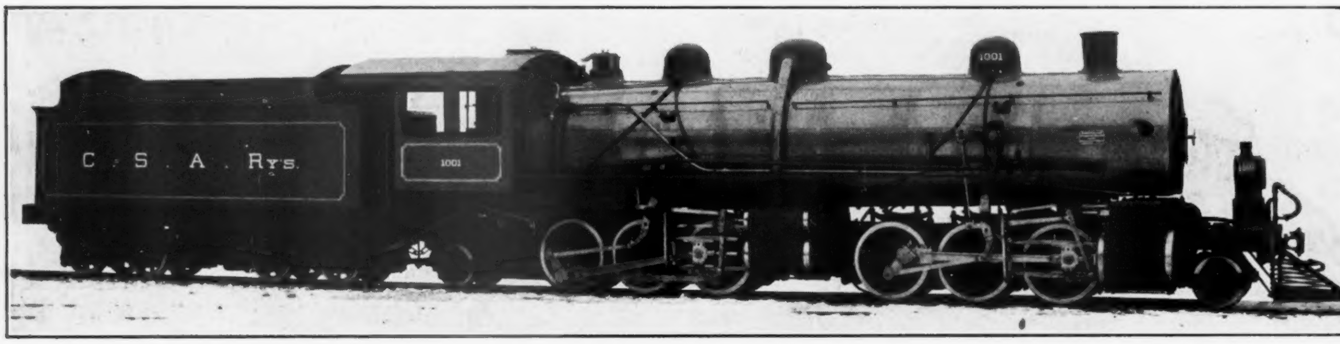
This company has recently completed another narrow gauge Mallet, that is to be put into service on the Central South African Railways, the conditions of which are very similar to those of the Natal Government Railways; the design in this case, however, being of the 2-6-6-2 type. In the same order are also included a large Pacific type locomotive, which in general design follows American practice and is provided with a fire tube superheater.

Referring first to the Mallet articulated compound locomotive.

The reversing mechanism is so arranged that the weights of the parts of the two sets of valve motions counter-balance each other. Reversing is effected by means of the builders' usual design of power reversing gear, except that in this case the reversing cylinder is operated by steam, as this engine is not equipped with compressed air.

Wrought iron frames four inches wide are used. The rear frames have a single front rail integral with the main frame, while the front frames are fitted with double front rails. There is a single articulated connection between the front and rear engines. That part of the weight of the boiler carried on the front system is supported by a single self-adjusting sliding bearing provided with the builders' usual design of spring centering device.

The three pairs of driving wheels of the front system are all equalized together and with the leading truck by a single central equalizing beam, while the rear set of driving wheels are equalized in a similar manner except that the cross equalization is omitted and each side is equalized with the trailing truck by



NARROW GAUGE MALLET COMPOUND LOCOMOTIVE—CENTRAL SOUTH AFRICAN RAILWAY.

It has a total weight of 225,000 lbs., of which 192,500 lbs. is carried on the driving wheels. As far as the features peculiar to the articulated type of construction is concerned, the design in general follows the builders' standard practice. The high pressure cylinders are 18 inches in diameter by 26 inches stroke, and the low pressure cylinders are 28½ inches in diameter by the same stroke. The exhaust passages of the low pressure cylinders are carried forward to the front of the cylinder, where they connect to the branches of a "Y" pipe. This has a ball joint connection with an elbow connected by a pipe fitted with a slip joint with an elbow having a ball joint connection with the exhaust pipe in the smoke box. This arrangement was necessary in order to secure a proper length of flexible exhaust pipe so as to reduce the angle of its deflections when the locomotive passes through sharp curves. In order to provide room between the top of the cylinder casting and the smoke box for the flexible exhaust pipe it was necessary in this case to provide an offset of 5⅜ inches in the bottom of the smoke box from a point 15½ inches back of the center line of the exhaust pipe.

Following the usual practice, the high pressure cylinders are equipped with piston valves and the low pressure with Allen-Richardson balanced slide valves, both being operated by a simple design of the Walschaert valve gear.

means of an equalizing beam which fits into a pocket in the truck center pin. This arrangement gives a three point suspended engine.

The boiler is of the radial stayed straight top type and the barrel measures 72⅛ inches in diameter inside at the first ring. The design incorporates an 18 inch combustion chamber, the bottom of which is laid with fire brick.

There are 271 tubes 2¼ inches in diameter and 20 feet long, which provide a heating surface of 3,167.7 sq. ft. The total heating surface of the boiler is 3,324.8 sq. ft. This gives a ratio of total heating surface to the volume of equivalent simple cylinders of 281. The firebox is 107 15/16 inches long and 66 inches wide, and provides a grate area of 49.5 sq. ft. Following English practice, the inside firebox is made of copper, the crown and side sheets being in one piece, and copper staybolts are used for the water-space stays.

Both trucks are of the radial center bearing, swing bolster type, with journals outside of the wheels. The bolster is suspended by 3-point or stable equilibrium hangers. The frame, which is of cast steel, of light but strong construction, is in three parts. The main frame has two arms on each side which extend outside of and partially surround the wheel, and between the ends of these arms the section forming the pedestal for the journal box

is securely bolted. Coil springs seated on top of the boxes transmit the loads to the journals.

As the engine is designed to pass through curves of 350 feet radius it was necessary, in order to provide the required truck swing and bring the point of support as low as possible, to suspend the bolster underneath the axle and employ a long center pin, which is built up in two parts, the lower one straddling the axle.

The Pacific type locomotive is the heaviest narrow gauge passenger engine on our records, and in working order has a total weight of 155,000 pounds, of which 106,000 pounds are carried on the driving wheels.

The design was prepared by the builders and follows, in general, American locomotive practice, which will afford an excellent opportunity for determining the relative efficiencies of the English and American designs by a comparison of the results obtained with the engine here illustrated and others of the same type built by English locomotive manufacturers.

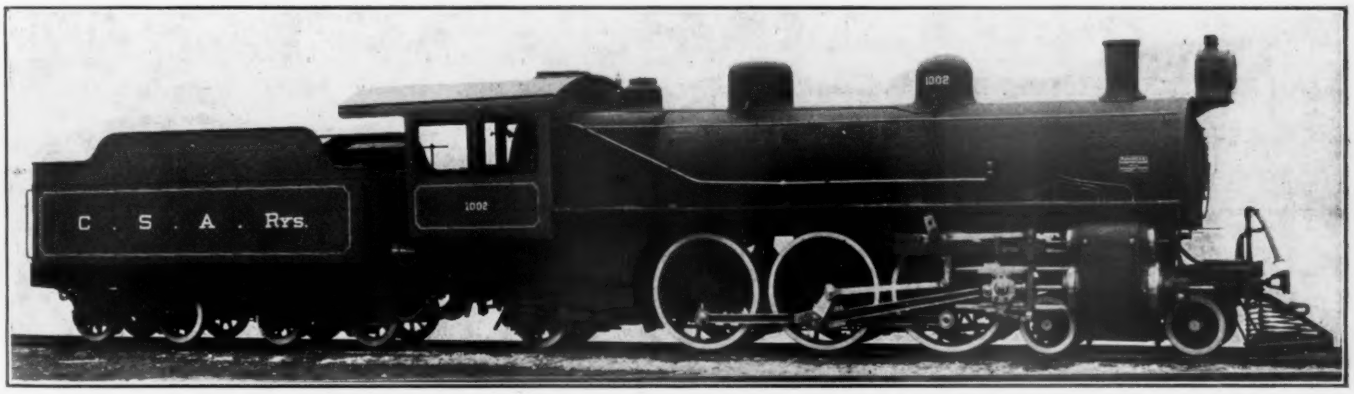
With 62 inch driving wheels and a maximum tractive effort of 28,800 pounds, the most difficult problem in connection with this design was to provide sufficient boiler capacity to meet the requirements without exceeding the maximum allowable height of 7 ft. 8 in. from the top of the rail to the center of the boiler. In this case the difficulty was very satisfactorily overcome by the application of highly superheated steam.

The superheater is the builders' latest design of fire tube type with side steam headers and of the double loop type arranged to give a high degree of superheat. It provides a heating surface of 363 square feet. This is 19 per cent. of the tube heating surface, which approximates very closely the ratio recommended by German locomotive designers, in which country the application of superheated steam has reached its highest development.

relation to the main and truck frames and in proper alignment with and full bearing on the journal boxes. This construction eliminates the necessity for outside supplementary trailing frames, thereby effecting a considerable reduction in weight, which in standard gauge trucks amounts to from 2,500 to 3,000 pounds.

The spring seat fits freely in a central opening formed in the spring seat guide and is carried on a trunnion block which passes freely through a longitudinal opening in the spring seat, and is provided with pivot ends carried in bearings bolted to the under side of the spring seat guide. The trunnion block is coupled to the spring seat by means of a transverse pin passing through both, the whole thus forming a universal joint connection. With this construction the spring seats can easily adjust themselves to any change in the position of the journal boxes relatively to the main frame. The spring seat guide slides between the jaws of the cast steel yoke, thus providing for the rise and fall of the journal boxes relatively to the main frame. Between the spring seat and the top of the journal box is interposed a cast iron friction plate. The upper surface of this plate is designed to form three inclined surfaces, the central sloping in an opposite direction to those on each side, but at the same angle. The corresponding surfaces of the spring seat are similarly inclined. This provides double inclined bearing surfaces, the action of which furnishes a resistance to the transverse movement of the truck, and assists the spring centering device in restoring the truck to its normal position when the locomotive enters a tangent after passing through a curve.

A boiler of the Belpaire type with a copper firebox in accordance with the usual English practice has been used. The throat sheet and back head are inclined so as to throw the center of gravity as far forward as possible, thereby bringing more weight on the driving wheels and reducing the load on the trailing truck.



POWERFUL NARROW GAUGE PACIFIC TYPE LOCOMOTIVE—CENTRAL SOUTH AFRICAN RAILWAY.

Full advantage has been taken of the application of highly superheated steam to use large cylinders and a low boiler pressure. The cylinders are 21 inches in diameter by 28 inch stroke, and the boiler carries a working pressure of 170 pounds per square inch.

Ten inch piston valves are employed; and following the most approved practice, both the valve and piston rods are provided with front extensions.

An interesting detail of the design is found in the new arrangement of the piston rod extension guide, which is so constructed as to be self-centering.

Another interesting feature of the design is the trailing truck, which is a modification of the company's new design of outside bearing radial truck that has been successfully applied to a number of recent Pacific type locomotives built by them. In the truck here applied the modification consists in the use of a spring yoke rigidly secured to the slab frame instead of one hinged to the frame. The important advantages of this type of trailing truck, as compared with the older type of outside bearing radial truck, are: greater simplicity of construction, material reduction in the dead weight of the engine, and a more perfect maintenance of the springs in their normal

The fire box is 78 inches long and 65 inches wide, and provides a grate area of 35 square feet. This gives a ratio of grate area to equivalent heating surface of 70.6. The firebox is supported by a steel expansion plate at the back end, while the support for the front end is furnished by a steel waist plate located just back of the rear pedestal.

The tender is of the 8-wheel type, being fitted with a U shaped tank having a water capacity of 4,000 gallons and space for 10 English tons of coal. The tender trucks are of the equalized pedestal type.

Steam brakes are applied to all the drivers, and in addition the engine is equipped with a vacuum brake which acts on the tender wheels and is provided with a connection for the train line.

The principal ratios and dimensions of both designs are given in the following table:

GENERAL DATA.

Type	2-6-6-2	4-6-2
Gauge	3 ft. 6 in.	3 ft. 6 in.
Service	Freight	Passenger
Fuel	Bit. Coal	Bit. Coal
Tractive effort	48,100 lbs.	28,800 lbs.
Weight in working order	225,000 lbs.	155,500 lbs.
Weight on drivers	192,500 lbs.	106,000 lbs.
Weight of engine and tender in working order	352,000 lbs.	259,800 lbs.

Type	2-6-6-2	4-6-2
Wheel base, driving	8 ft. 4 in.	11 ft. 2 in.
Wheel base, total	40 ft. 3 in.	29 ft. 8 in.
Wheel base, engine and tender	65 ft. 6 in.	54 ft. 11¾ in.
RATIOS.		
Weight on drivers ÷ tractive effort	4.09	3.68
Total weight ÷ tractive effort	4.68	5.40
Tractive effort × diam. drivers ÷ heating surface	666.00	901.00
Total heating surface ÷ grate area	67.00	56.60
Firebox heating surface ÷ total heating surface, %	4.70	6.70
Weight on drivers ÷ total heating surface	57.80	53.50
Total weight ÷ total heating surface	67.60	78.50
Volume equiv. simple cylinders, cu. ft	11.80	11.20
Total heating surface ÷ vol. equiv. cylinders	281.00	177.00
Grate area ÷ vol. equiv. cylinders	4.20	3.12
CYLINDERS.		
Kind	Compound	Simple
Diameter and stroke	18 & 28½ x 26 in.	21 x 28 in.
VALVES.		
Kind, H. P	Piston	Piston
Kind, L. P	Slide	——
Greatest travel, H. P	5 in.	5½ in.
Greatest travel, L. P	5½ in.	——
Outside lap, H. P	1 in.	1 in.
Outside lap, L. P	⅞ in.	——
Inside clearance	3/16 in.	⅛ in.
Lead in full gear	3/16 in.	¼ in.
WHEELS.		
Driving, diameter over tires	46 in.	62 in.
Driving, thickness of tires	3 in.	3 in.
Driving journals, main, diameter and length	8 x 10 in.	9 x 10 in.
Driving journals, others, diameter and length	8 x 10 in.	8 x 10 in.
Engine truck wheels, diameter	28½ in.	28½ in.
Engine truck, journals	5½ x 10 in.	5 x 8 in.
Trailing truck wheels, diameter	28½ in.	33 in.
Trailing truck journals	5½ x 10 in.	6 x 12 in.
BOILER.		
Style	Straight	Belpaire
Working pressure	200 lbs.	170 lbs.
Outside diameter of first ring	73¾ in.	62 in.
Firebox, length and width	108 x 66 in.	78 x 65 in.
Firebox plates, thickness	½ in.	½ in.
Tube plates, thickness	1 & ½ in.	1 & ½ in.
Firebox, water space	F. 4, S. & B. 3½ in.	F. 4, S. & B., 3 in.
Tubes, number and outside diameter	271—2¼ in.	132—2¼ in.
Tubes, length	20 ft.	18 ft. 2 in.
Heating surface, tubes	3,167.7 sq. ft.	1,848 sq. ft.
Heating surface, firebox	156 sq. ft.	135 sq. ft.
Heating surface, total	3,324.2 sq. ft.	1,981 sq. ft.
Superheater heating surface	——	363 sq. ft.
Grate area	49.5 sq. ft.	35 sq. ft.
Smokestack, diameter	17 in.	14½ in.
Smokestack, height above rail	12 ft. 10⅜ in.	12 ft. 9¼ in.
TENDER.		
Wheels, diameter	33½ in.	33½ in.
Journals, diameter and length	5½ x 10⅛ in.	5 x 9 in.
Water capacity	5,000 gals.	4,000 gals.
Coal capacity	10 long tons	10 long tons

AN ELECTRIC STORAGE BATTERY CAR

Edison nickel-iron storage batteries have been in use for several years in automobile service with excellent results and have recently been arranged for driving street cars, the illustration showing the exterior and interior appearance of a car, which has been in experimental use for several months and has recently been put into service on the 28th and 29th street lines in New York City, displacing some of the horse cars. It has been found to work well on grades of 8 per cent. and has been driven up a 10 per cent. grade. The cost of current in this service has proven to be but two cents per car mile.

It is of the single truck vestibule type, the body being very carefully designed to obtain minimum weight. There are no body end doors, the vestibule being completely closed instead. Hand rails of white enameled steel have been installed to serve in place of straps, to help carry the roof and to hold the lighting fixtures. The lighting wires are enclosed in these tubes and no lighting fixtures are carried from the extremely light roof.

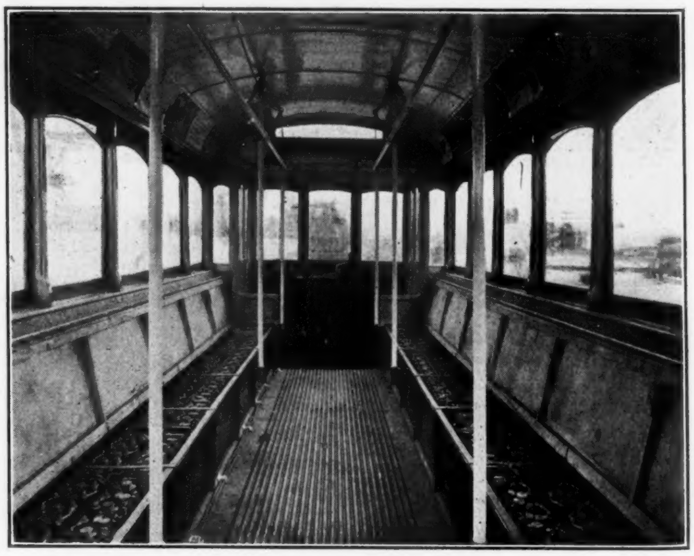
The car body is mounted on a single four-wheel truck of 6 ft. 6 in. wheelbase. The truck frame is of steel shapes welded at all joints by the oxy-acetylene process. The journal housing and all castings are of steel. The bearings are of the ordinary railway type, but were ground with extra care. The truck axles are of 2½-in. diameter steel and are divided in the center, a steel aligning sleeve being provided to permit the free rotation of each wheel with respect to its mate, as in automobile designs. It is believed that considerable power will be saved by using this form of axle. The wheels are of steel 28 in. diameter. Telescope steel spring seats are provided between the truck and the car body, thereby giving a free upward movement, but confining the side and end swaying to within ⅛ in. This reduction in the side and end movement has also greatly simplified the braking mechanism.

The batteries are placed under the longitudinal seats in a lattice steel electrically-welded girder frame weighing 153 lb. The frame on each side forms a box for the batteries, a support for the side posts and a firm bracing for the entire car. Each frame is bolted to the adjacent cross sills, side sills, side posts and end bulkheads, and through its connection with the vertical hand rails it helps to carry the roof. It has been found that, as a result of this novel construction, there is only a deflection of .003 in. when the car body carries a load of two tons in the center.

The storage battery consists of 200 type A-4 cells for traction and 10 cells for lighting. These cells are separately connected when working, but are in series when they are being

STORAGE BATTERY STREET CAR.

charged. This arrangement keeps the lights immune from variations in voltage when the car is running. The capacity of the battery is such that it can run the car for 150 miles without recharging. The motor equipment now mounted on the truck consists of two 5-h.p. 110-volt motors of Northern Electric manufacture, capable of attaining a maximum speed of 15 m.p.h. and a scheduled speed of 8 m.p.h. when there is an average of 14 stops per mile. The motors are connected to opposite axles by Renold chains. The truck can be used to carry four motors driven independent, one for each wheel, if desired. The controllers are of the Cutler-Hammer type arranged as follows: First step, batteries in multiple at 50 volts, motors in series;



INTERIOR SHOWING STORAGE BATTERIES UNDER THE SEATS.

second step, batteries in multiple at 100 volts, motors in series; third step, batteries at 100 volts, motors in multiple. It will be understood that no fixed resistances are used as the voltage is built up through cell combinations. The power consumption of this car when accelerating at 1 m.p.h.p.s. is about 3½ kw. and when running about 1½ kw. The weights of the several parts are as follows: Car body, 3,500 lb.; truck and electrical equipment, including two motors, 3,500 lb.; batteries, 3,000 lb. Adding

the weight of 26 seated passengers at 150 lb. each, gives the equipment a total weight of 13,900 lb.

The car body, truck and equipment were designed by Ralph H. Beach, of the Edison Storage Battery Company, New York.

Signal Instruction Cars.—The Pennsylvania Railroad has just equipped the divisions between Philadelphia and Pittsburgh with cars fitted with apparatus for giving instruction and examination in signals of all kinds.

THE RAILROAD CLUBS.

Club	Next Meeting	Title of Paper	Author	Secretary	Address
Canadian	May 3	Annual Meeting, Election of Officers		Jas. Powell	P. O. Box 7, St. Lamberts, Montreal, Que.
Central	May 13	Present Status and Tendencies of Railroad Electrification in America	F. Darlington	H. D. Vought	95 Liberty St., New York
New England	May 10			G. H. Frazier	10 Oliver St., Boston, Mass.
New York	May 20	Inequalities of Expansion in Locomotive Boilers and Possibilities of Eliminating the Bad Effect Therefrom	D. R. McBain	H. D. Vought	95 Liberty St., New York
Northern	May 28	Traffic	G. Roy Hall	C. L. Kennedy	401 W. Superior St., Duluth, Minn.
Pittsburgh	May 20	Steam Turbines	E. M. Herr	C. W. Alleman	P. & L. E. R. R. Gen. Office, Pittsburgh, Pa.
Richmond	May 9	Entertainment		F. O. Robinson	C. & O. Ry., Richmond, Va.
Southern	May 19			A. J. Merrill	218 Prudential Bldg., Atlanta, Ga.
St. Louis	May 13			B. W. Frauenthal	Union Station, St. Louis, Mo.
Western	May 17			J. W. Taylor	390 Old Colony Bldg., Chicago
Western Canada	May 9	Should the Brake Power on Freight Cars Be Increased?	Thos. Clegg	W. H. Rosevear	199 Chestnut St., Winnipeg, Man.

M. C. B. RULES OF INTERCHANGE.

NEW ENGLAND RAILROAD CLUB.

At the March meeting of this club a committee consisting of J. W. Marden, J. E. Sheehan, and Edmund Rice presented a report to the effect that the New England Railroad Club recommended a method of interchange known as "the repair, run or transfer system," which will make car owners responsible for the cost of repairs of all defects, except those caused by derailment or wreck. This report was discussed at some length, there being advocates of accepting it as it stood and also of amending it. The M. C. B. rules of interchange were very thoroughly discussed in this connection and it was finally voted to accept the report of the committee and forward it to the arbitration committee of the M. C. B. Association.

The annual report of the secretary showed a membership of 527 and the treasurer's report showed a balance of over $1,700 on hand. The following officers were elected: President, John Lindall, Supt. R. S. & S., Boston Elevated Ry.; vice-president, J. A. Droege, Supt., N. Y., N. H. & H. R. R.; treasurer, Chas. W. Sherburne.

THE STRESSES DEVELOPED BY COLLISION OF FREIGHT CARS.

NEW YORK RAILROAD CLUB.

Col. B. W. Dunn presented an excellent paper on the above subject at the April meeting of this club. The theory was discussed at some length and following this the results obtained by a series of tests on the Pennsylvania Railroad were presented. An abstract of this paper will be given in a later issue of this journal.

THE FUNDAMENTAL PRINCIPLES OF EFFICIENCY.

RAILWAY CLUB OF PITTSBURGH.

Harrington Emerson presented a brief but most comprehensive paper at the February meeting of this club. In it the laws governing the principles of efficiency were condensed to eight in number, each being named and briefly discussed by the author.

This paper was discussed at some length by L. H. Turner, whose remarks are well summed up in the following quotation: "Our country is suffering from too many 'short time record makers' giving short spectacular performances but who eventually sink into obscurity. Every mechanical man in charge of a large equipment is prompted not only by personal pride but by desire to maintain a good position among other lines for the cost of maintenance; he is willing and glad to follow any new methods that will aid him, but does not like to have impossible performances held up as a model for his guidance. The work in which Mr. Emerson is engaged should be prolific with good results, but we believe he has placed his standards too high and has aimed at results which can never be attained and in consequence are not taken seriously."

The paper was also discussed at some length by I. B. Thomas, William Elmer, P. J. Conlon, F. H. Stark, W. L. Kinsell, W. J. Powers, W. J. Schlacks, and others.

ECONOMY IN LOCOMOTIVE REPAIR SHOPS.

WESTERN CANADA RAILWAY CLUB.

W. R. Smith, general foreman of the Canadian Northern Railway shops, presented a paper on the above subject at the March meeting of this club. He considered a number of different features in connection with repair shops, where a little study would bring about very large savings. Among these were the use of the crane over the yard where heavy material is stored, doing away with the services of a large number of men, and the purchasing of the proper grade and quantity of material. The expense from delay of delivery of ordered material was shown to be very large and the matter of proper form for accounts was considered at some length, a description of the method being used on the Canadian Northern Railway being given. A spirited and general discussion, which added much to the value of the paper, followed its presentation. Men from all different departments suggested ways in which economies could be made.

ECONOMICAL AND PROPER HANDLING OF MATERIAL IN THE STOREHOUSE.

NORTHERN RAILWAY CLUB.

J. E. Chandler, storekeeper of the Duluth & Iron Range Railroad, presented a paper at the February meeting of the above club which briefly considered a few features in connection with the proper handling of storehouse material. Attention was drawn to improper practices that have become customary on most railroads.

ANNUAL MEETING.

ST. LOUIS RAILWAY CLUB.

At the annual meeting of the above club on April 8 the following officers were elected: President, E. A. Chenery; first vice-president, H. G. Pfeifer; second vice-president, Charles Burlingame; third vice-president, J. P. Carothers; secretary, B. W. Frauenthal; treasurer, C. H. Scarritt; members of executive committee, W. H. Elliott and Tipton Stilwell.

Secretary Frauenthal's annual report showed that the present membership is 1,185, and that the club has a balance in its treasury of $3,737.08. He stated that the present holder of the club's scholarship will graduate from the University of Missouri this year and that the executive committee desired to bring before the members the necessity of selecting another person for the scholarship and of designating the institution to which he shall be assigned, so that the members may aid the committee in taking proper action.

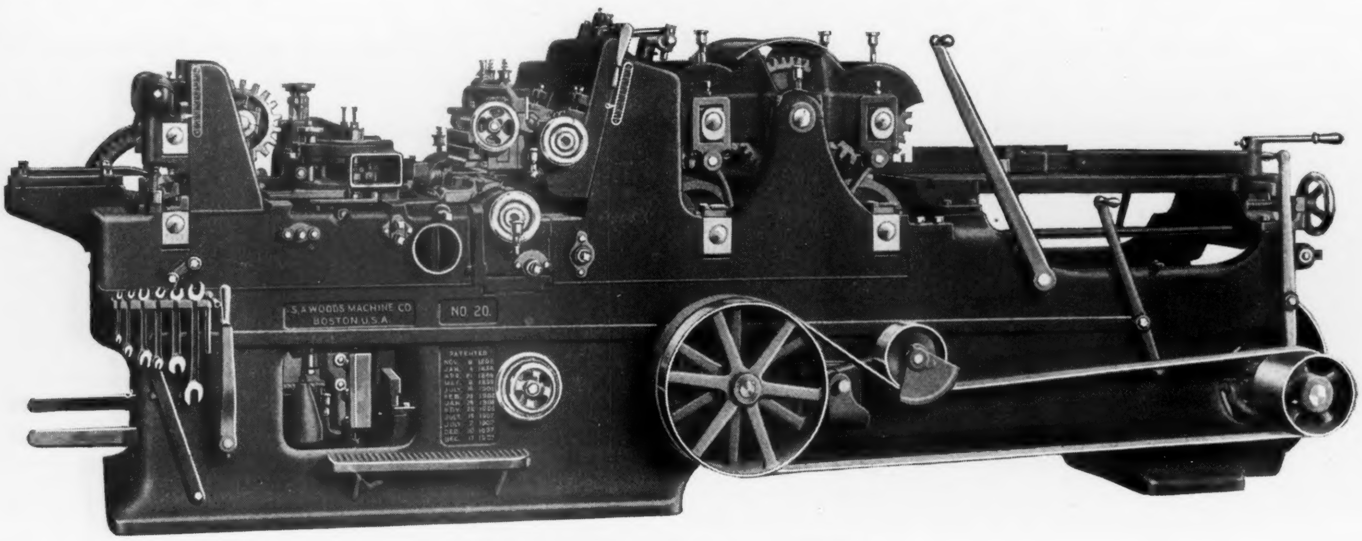
A DEPARTURE IN PLANING MACHINE CONSTRUCTION.

The rapid production and high grade finish demanded in the output of the modern planing mill and car shop has made necessary and induced the adoption and development of new features to displace many older features of construction that in the past had been accepted without question. But the possibilities of perfect cutterhead work and rapid feed have been appreciated within a comparatively short time, and the development of planing machines to take advantage of the latest devices is still more recent.

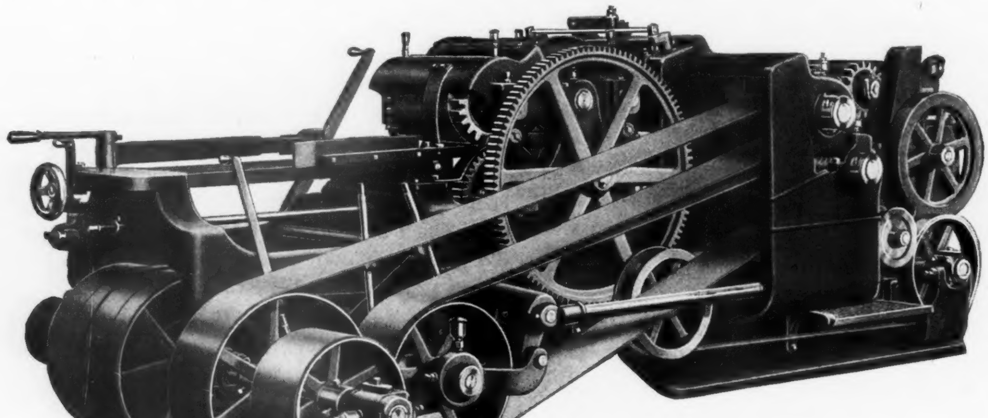
One of the greatest difficulties in obtaining perfect cutterhead work has been due to the almost impossibility of maintaining the proper condition in the cutterhead journals. It is known that under the high speeds of planing machine cylinders and the increased size of belts necessary for fast feed, the wear of the journals is very rapid and soon destroys the accuracy of any adjustment that may be made. Then again the lubrication of long cutterhead boxes has always been considered a very difficult problem and almost impossible of attaining to any degree of satisfaction or reliability. When it is considered that the pull of the cutterhead belts while working may be as high as 1,500 pounds and the journal speed as high as 3,200 feet per minute, under these strains it is not surprising that a great deal of difficulty is experienced.

Another element of the difficulty has been experienced in the vibrations and jars of the cutterheads caused by the belts on the shafts, this factor being one of the most serious and difficult to eliminate. It was not unusual to see the mark left by the belt lacing on the stock each time that it went over the pulley. The difficulty of making two belts run exactly alike also added to the troubles attending the method of belting cutterheads. The importance of the factor of belt slippage in the problem will be appreciated when it is considered that a difference of .01 of an inch in the diameter of the cutterhead pulleys means a difference of from ten to twelve feet in the amount of belt travel at the ordinary planing mill speeds, the difference being exaggerated by variations in thickness and tension of belts.

The necessity of the operator's working about the cutterheads in truing them off while they are running at full speed made the belting of cutterheads on the front or operating side of the machine somewhat dangerous, and accidents to operators have resulted from the breaking of belts while the operator was in the line of belting.



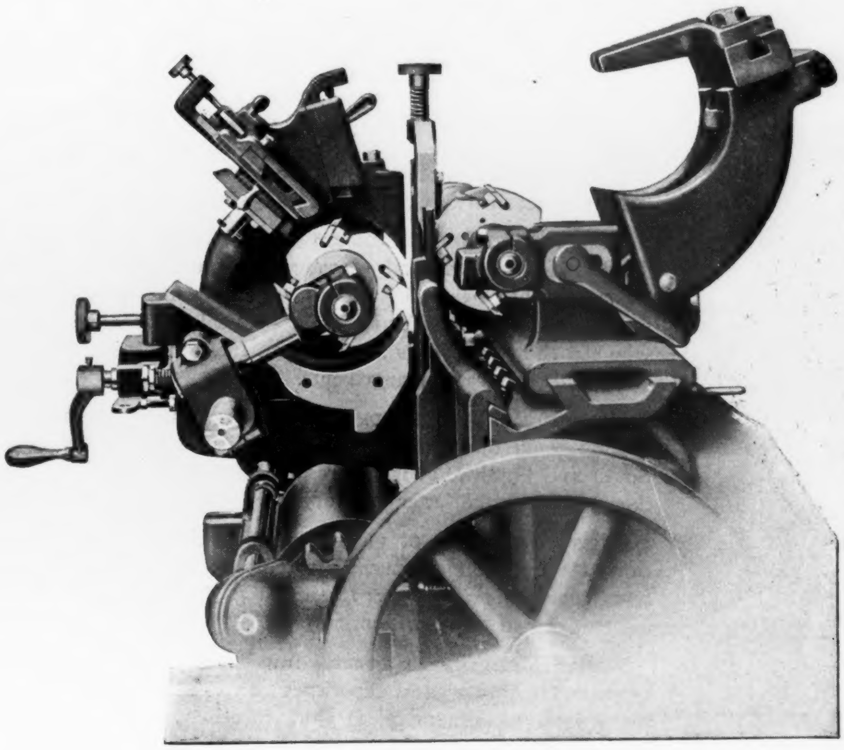
NEW PLANING MACHINE—S. A. WOODS CO.



REAR VIEW OF NEW PLANING MACHINE.

Convenience and accessibility on the operating side of any machine, allowing the removal of the cutterheads, taking out defective pieces, etc., are desirable. To accomplish these results, to eliminate the objectionable features of belting upon the cutterhead direct, and of belting troubles generally, the S. A. Woods Machine Company, Boston, Mass., has developed its one-side coupled drive, in which one belt is used for each cutterhead, and

the belts are placed on the back side of the machine, each driving a cutterhead pulley supported by boxes entirely independent of the cutterhead itself, a connection being made between the two by a flexible coupling. This coupling is claimed to absorb all vibrations transmitted to the pulley by the belting, thus leaving the cutterhead journals without the strain of the belts or other disturbing influences.



BEADING OR PROFILING ATTACHMENT FOR PLANING MACHINES.

This improvement permits the use of very short journals upon the cutterhead, these journals being efficiently lubricated by improved oiling devices, thus rendering easy the maintenance of ideal running conditions. This design also makes possible the instant detaching of the cutterhead from the spindle, leaving it free to be turned when setting up and without disturbing the belts in any way. Another new feature embodied in this one side driven planer is the new Woods Beading or Profile attachment which can be applied at the feeding out end of the machine. This new attachment carries all the knives for taking the formed cuts usually done on the top and bottom heads, and enables the operator to keep the full number of straight knives on these heads, ready for all classes of work. At the high speeds planers are now being run, when it is desired to work profile cuts with the formed knives on the top or bottom heads, it is necessary to greatly reduce the feeds. The new beading or profile attachment has been brought out to eliminate this.

The attachment is placed at the feeding out end of the machine and is made either single or double, as desired. The upper attachment is provided with a shoe or chip breaker, which rides upon the face of the stock, and is at all times positioned thereby. the cutterhead has a fixed relation to this shoe and any variation in stock does not effect the depth of cut taken. It will thus be seen that no damage can be done to the attachment if more than one piece of stock should be fed to it at a time. Vertical adjustment is provided for the cutterhead spindle, to regulate the cut. Both heads may be adjusted horizontally or vertically while in operation, and the attachment may be instantly put into or taken out of operation while the machine is running. Thus when it is desired to change from working siding or formed stock to flooring, or vice versa, the change is made very quickly. A detachable end bearing is provided for each spindle for steadying it, and suitable guides are furnished. The cutterheads are circular discs of steel, the width depending upon the size of cutters required. They are fitted with clamps and may be located at any point on the spindles. High speed steel cutters are used and quick means are provided for adjusting with relation to each other. The bottom table is arranged to swing down for accessibility to the heads.

The S. A. Woods Machine Company may be said to have fairly earned the title of "Planer Specialists" by concentrating its attention upon wood planers, and the No. 20 is the practical result of this specializing and the concrete demonstration of the higher efficiency to be attained through such concentration. Millmen who are contemplating the installing of planers will do well to look into this new type of machine.

HYDRAULIC BENDING MACHINE

For bending pipe, structural sections, metal bars, etc., the Watson Stillman Co., of New York, have recently perfected a very powerful hydraulic machine which is made in two sizes. The frames and cylinders are of cast iron, the latter being copper lined. The rams and bending pins are of machinery steel and a positive stop is provided to prevent the ram from passing out beyond a safe limit.

The illustration shows the smaller size of this machine, which is capable of exerting a power of 25 tons under a hydraulic pressure of 2,200 lbs. per square inch. The table is 2 ft. long by 3 ft. 4 in. wide and is provided with 18 round holes staggered in rows which are symmetrically placed with respect to the ram; 3½ in. diameter pins can be placed in any of the holes or the work can be held by bolts set in the slots on the top and sides of the table. The ram has a travel of 8 in. and is provided with a counterweight for bringing it back to the beginning of the stroke. Its center is customarily 2½ in. above the table, but can be varied if desired. The operation of the ram is controlled by a stop and release valve at the side of the cylinder.

HYDRAULIC PIPE BENDER.

The larger sized bender exerts a 30-ton pressure and has a table 4 ft. wide by 6 ft. long. In this case there are two opposed 7-in. cylinders of 12-in. stroke, arranged to operate in either direction. The double-headed ram extends between them and works in machined guides in the top of the table, its top being flush with that of the table. It carries a large vertical bending pin. The operation of this press can be controlled by levers at either corner of the table. It works in general in the same manner as the smaller size, the table having 21 holes staggered in six rows.

ADJUSTABLE SPEED MOTORS FOR DRIVING MACHINE TOOLS.

To successfully operate the majority of machine tools, a motor having a wide range of speed is desirable and such motors are now being specified very generally. To answer this demand

TRIUMPH CONSTANT SPEED MOTOR.

the Triumph Electric Company, of Cincinnati, has developed an adjustable speed motor, the special features of which are as follows: Wide adjustment of speed, constant speed maintained at any given speed, constant horse power at any speed, heavy overload capacity, and motor will run without sparking at any speed or load within the capacity of the motor and in either direction of rotation without shifting the brushes, which are immovably fixed.

The sparkless feature is obtained by means of commutation poles placed midway between the main field poles and wound with coils in series with the armature, so that the strength of these poles depends upon the load on the motor and is therefore

SECTIONAL VIEW OF TRIUMPH CONSTANT SPEED MOTOR SHOWING COMPENSATING COILS.

proportional to the armature reaction. This is true irrespective of the direction of rotation, so that the points of commutation are always in a field of such magnetic strength that sparkless commutation at all loads and all speed variations is obtained. This method of construction permits heavy overloads to be carried with ease and safety.

The illustration shows one of these motors with the front bracket removed and reveals the commutation poles. The absolutely sparkless operation insures long life for the commutator, smoother running for the motor, and less wear and tear on the brushes. Higher efficiencies are also obtained, due to the lower iron and commutator losses.

These motors develop the greatest torque at the lowest speed, and since the majority of machine tools require a heavy starting torque, they are especially suited for this purpose.

MEN WANTED.

Young technical graduates to learn the steel foundry business; excellent opportunity for men of the right character; also draftsmen experienced in railroad designing.

POSITIONS WANTED.

Designer with a railroad supply company; has had long and very thorough experience in railroad shops and drafting rooms and can furnish excellent references as to ability; at present chief draftsman with one of the largest railway systems.

Assistant to Superintendent of Motive Power or General Inspector—Man with 20 years' railroad experience; technical education; has held all positions, from fireman to master mechanic, and from machinist to mechanical engineer; a hustler who can show results; is an expert on fuel tests, spark throwing, front end and draft arrangements.

Mechanical Engineer or Chief Draftsman.—Has had long experience in the drafting room of railways principally in the South and Southwest; is at present chief draftsman on one of the systems in the latter territory.

Chief Draftsman, or outside work requiring similar qualifications by a technical man; seven years' railroad experience; now employed on a western railroad as leading draftsman on locomotive and electrical work.

Master Mechanic or general inspector; technical man with 15 years valuable general experience; occupied position as round house foreman, general piece work inspector, general foreman, master mechanic, general inspector, assistant city editor and financial editor on metropolitan paper, wishes position after July 10. when he will return from a tour of inspection on foreign railroads.

Chief Draftsman, or assistant master mechanic; Purdue graduate, experienced in all motive power departments; served as roundhouse foreman, shop investigator and other similar positions; is willing to go into the supply business, but prefers railroad work; salary over $150 per month.

BOOK NOTES.

Engineering Index Annual, 1909. Bound in cloth. 471 pages. 6½ by 9½ in. Published by the *Engineering Magazine*, 140 Nassau street, New York. Price, $2.00.

This forms the fourth volume of the annual and the eighth in the series of the index, which combined gives a continuous index of the engineering and technical literature for the past 26 years. While in general it follows the same scheme of classification that has proved so successful in previous annuals, the classification in this volume has been somewhat amplified and cross references have been more freely used. It incorporates references to practically every article of value that has appeared in any of the scientific or technical magazines during the past year and is based upon the monthly indexes published in the *Engineering Magazine*. The fact that it has not been found advisable to change the classifications is a good indication of their satisfactory arrangement and selection. No engineer's library can possibly be considered complete without a set of these indexes.

Valve-Setters' Guide. By James Kennedy. Cloth. 5½ by 7 in. 57 pages. Illustrated. Published by Angus Sinclair Co., 114 Liberty street, New York. Price, 50 cents.

This book considers at some length the construction and adjustment of the principal valve gears used on American locomotives. It describes the arrangement of the different designs by means of illustrations and contains instructions for the proper procedure in setting valves with each.

PERSONALS.

H. F. Smith has been appointed a master car builder of the Chicago & Alton R. R., with office at Bloomington, Ill.

J. M. Burke has been appointed district master mechanic of the Atlantic division, Canadian Pacific Ry., with office at Brownsville Jct., Me.

C. W. Van Buren has been appointed master car builder of the eastern lines of the Canadian Pacific Ry., with office at Montreal, Que.

Charles H. Bilty has been appointed mechanical engineer of the Chicago, Milwaukee and St. Paul Ry., succeeding J. F. DeVoy, promoted.

F. F. Patterson has been appointed district master mechanic of the western division, Canadian Pacific Ry., with office at Moose Jaw, Sask.

H. G. Huber, assistant master mechanic of the Pennsylvania R. R. at Philadelphia, has been transferred to Harrisburg, succeeding W. J. Rusling.

R. A. Pyne, master mechanic of the Canadian Pacific Ry. at Nelson, B. C., has been transferred to Calgary, Alta., succeeding W. E. Woodhouse, promoted.

W. L. Harrison, superintendent of motive power of the Northern district, Rock Island Lines at Cedar Rapids, Iowa, has resigned to enter into private business.

E. H. Wade, master mechanic of the Chicago & North Western Ry. at Chicago, has been appointed supervisor of locomotives, with office at Green Bay, Wis.

C. M. Taylor, superintendent of motive power of the Rock Island Lines at Shawnee, Okla., has had his jurisdiction extended over the entire Southern district.

W. J. Rusling, assistant master mechanic of the Pennsylvania Railroad at Harrisburg, Pa., has been appointed foreman of the Enola, Pa., shops, succeeding H. T. Coates, Jr., promoted.

P. A. Crysler, formerly general car inspector, Canadian Pacific Ry. Eastern Lines, has been appointed assistant general foreman of passenger car repair work at the Angus shops, Montreal.

D. T. Main, heretofore locomotive foreman on the Canadian Pacific Ry. at Cranbrook, B. C., has been appointed district master mechanic at Nelson, B. C., suceeding R. A. Pyne, promoted.

W. J. O'Neill, master mechanic of the Chicago, Rock Island and Pacific Ry. at Fort Worth, Tex., has been transferred to the Louisiana division at Eldorado, Ark., succeeding C. A. McCarthy.

Walter Liddell, general foreman in the locomotive department of the Chicago, Milwaukee and St. Paul Ry. at Dubuque, has been appointed master mechanic, succeeding J. J. Connors, promoted.

C. A. McCarthy, master mechanic of the Louisiana division of the Chicago, Rock Island and Pacific Ry. at Eldorado, Ark., has been transferred to the Arkansas division, with office at Argenta, Ark.

Tom Brown, formerly master mechanic of the Juniata shops of the Pennsylvania Railroad at Altoona, has been appointed a special representative of the Westinghouse Air Brake Company, with headquarters at 165 Broadway, New York City.

Frank Hufsmith, formerly superintendent of motive power of the International & Great Northern Ry., has been made receiver of the Oklahoma, Red River & Texas Ry., with office at Palestine, Texas.

F. J. Harrison, division master mechanic of the Buffalo, Rochester & Pittsburgh Ry., has been appointed superintendent of motive power, with office at Du Bois, Pa., suceeding W. H. Wilson, resigned.

W. H. Williams, master mechanic of the Buffalo, Rochester & Pittsburgh Ry. at East Salamanca, N. Y., has been appointed master mechanic of the Middle and Pittsburgh divisions, with office at Du Bois, Pa.

T. J. Hamilton has been appointed district master mechanic of the Chicago, Milwaukee & Puget Sound Ry., with office at Deer Lodge, Mont. He will have charge of the line between Harlowtown, Mont., and Avery, Idaho.

J. J. Connors, district master mechanic of the Chicago, Milwaukee and St. Paul Ry. at Dubuque, Iowa, has been appointed assistant superintendent of motive power of the lines west of the Mississippi river, with office at Dubuque.

James F. DeVoy, mechanical engineer of the Chicago, Milwaukee & St. Paul Ry. at Milwaukee, Wis., has been appointed assistant superintendent of motive power of the lines east of the Mississippi river, with office at Milwaukee.

F. W. Williams, superintendent of motive power of the Southern district of the Rock Island Lines at Fort Worth, Tex., has been transferred to the Northern district, with office at Cedar Rapids, Iowa, succeeding W. L. Harrison, resigned.

E. J. Harris, master mechanic of the Iowa and Des Moines Valley divisions of the Rock Island Lines at Valley Junction, Iowa, has been appointed master mechanic of the Kansas City Terminal and the St. Louis division at Armourdale, Kan.

T. W. McCarthy, master mechanic of the Arkansas division of the Chicago, Rock Island and Pacific Ry. at Little Rock, Ark., has been appointed master mechanic of the Indiana Territory and the Pan Handle divisions, with office at Shawnee, Okla.

LeGrand Parish, who since 1906 has been superintendent of motive power on the Lake Shore and Michigan Southern Ry., has resigned to accept the presidency of the newly organized American Arch Co., which hereafter will conduct the business of the American Locomotive Equipment Co. of Chicago and the brick arch department of the Franklin Railway Supply Co. Mr. Parish was born at Friendship, N. Y., in 1866. His railroad career has been one of unusual activity and brilliancy. He entered the service of the Lake Shore and Michigan Southern in 1889, since which time he has been chief clerk of the car department, general foreman, master car builder, assistant superintendent of motive power, and superintendent of motive power. His remarkable rise can be attributed largely to his unusual ability as an organizer. For a number of years Mr. Parish has taken an active part in the affairs of the Master Car Builders' and the Master Mechanics' Associations. At present he is second vice-president of the former and he also, at one time, served a term as president of the Western Railway Club. The officers of the American Arch Company are: J. S. Coffin, chairman; LeGrand Parish, president; Charles B. Moore, vice-president; Samuel G Allen, secretary and treasurer. The principal office of the company will be at 30 Church street, New York, with branch offices at Chicago, St. Paul, Omaha, Denver, Los Angeles and at San Francisco.

CATALOGS.

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

Transite Asbestos Wood.—The uses of this wood are discussed in a circular from the H. W. Johns-Manville Company, New York City. It is said to give splendid results when used for smoke jacks.

Valves.—A new leaflet is issued by Jenkins Bros., New York, describing their quick opening Globe and Angle Valves. These valves are of the same high quality and similar in design to the regular Jenkins valves except that the spindles and bonnets are quadruple threaded with a coarse pitch.

Electric Forge Blower.—The B. F. Sturtevant Co. are sending out Bulletin No. 177, which illustrates and describes their new Electric Multivane Forge Blower. It is claimed that this method of forge blowing possesses many advantages over the method where a larger blower takes care of several forges.

Vertical Turret Lathes.—A very interesting pamphlet marked V-16, entitled "The Vertical Turret Lathe for Machining Automobile and Gas Engine Parts" describes this new tool made by the Bullard Machine Tool Co., Bridgeport, Conn. It also contains a number of very good line drawings showing clearly the different operations in machining such parts.

Wood's Locomotive Fire Box.—A pamphlet is being issued by the William H. Wood Locomotive Fire Box & Tube Plate Company, Media, Pa., which is given up largely to the reproduction of letters from various railroad men concerning service and opinions on the value of this type of fire box for locomotive use. These letters are, in general, very complimentary to the value of this type of construction.

Burning Fuel Oil.—The Springfield process for burning fuel oil under low pressure is very fully explained in an attractive manner by a catalog being issued by Gilbert & Barker Mfg. Co., Springfield, Mass. This process is remarkably simple and is largely automatic. It gives practically perfect combustion with furnaces which require no combustion chamber and are large enough for the material to be heated and no larger.

Motor Cars.—Fairbanks, Morse & Co., Chicago, have just issued a very artistic catalog showing their gasoline motor cars, both for passenger service and inspection purposes. The catalog is probably one of the best books of its nature ever issued and is particularly interesting because the cars shown represent the progress in the manufacture of gasoline cars for track use, including the different types for all requirements of railroad work.

Barium-Choloride Furnace.—A leaflet is being issued by the Rockwell Furnace Co., New York, illustrating and describing the Barium-Choloride furnace that uses either oil or gas fuel for heating high speed steel tools, milling cutters, taps, dies, etc., for hardening. It will maintain a bath at uniform temperature that is under the accurate control of the operator, and largely eliminates the risk usually experienced in hardening high speed tool steels.

Rotary Converters.—Bulletin No. 4723, recently issued by the General Electric Co., gives a very good description of the regulating pole rotary converter, which they have developed to simplify the wiring arrangements and to reduce the cost of auxiliary devices where the use of converters in connection with electric lighting and industrial power plants necessitates a variable ratio between the alternating and direct current voltages for charging storage batteries and other special requirements.

Bolt Cutters.—Catalog No. 46 from the Newton Machine Tool Works, Philadelphia, describes a new Multiple Automatic Die Head very suitable for round house and repair shop work. This head is flexible in that it is fitted with chasers which are interchangeable, for four sizes of bolts, yet retaining the rigidity and accuracy of a solid die. The catalog also contains some good illustrations of bolt threading machines, rotary planers, cold saws, horizontal milling machines, and a duplex rod boring machine.

Tool Steel.—Number 10 of "Ryerson's New Technical Library," being issued by Joseph T. Ryerson & Son, Chicago, is a 64-page booklet containing a complete description of the various kinds of high speed and carbon tool steel that is handled by that company, together with complete directions for treating to insure the best results. In addition there are several pages devoted to tables of useful information in connection with steel. This company handles thirteen different kinds of tool steel, several of which can be obtained in different grades.

Bolt Cutting and Forging Machines.—The Acme Machinery Co., Cleveland, O., is issuing a standard size catalog containing 162 pages given up to illustrations and descriptions of bolt cutting, nut tapping and forging machines. The detail construction of each of these machines is clearly shown by wash drawings and is discussed in a very thorough and interesting manner on adjoining pages. The processes of manufacture are considered in most cases, indicating the care with which the machines are made. Bolt cutters in many sizes and capacities are shown that are fitted with the new special adjustment Acme die heads, which are said to be the most important advance made in the construction of these machines in a long time. The nut tappers are illustrated in a similar manner, as are also the forging machines. This is a most interesting and valuable catalog.

Boring Mills.—Vertical boring and turning mills in any size ranging from 30 to 84 inch, inclusive, are attractively presented in a catalog just issued by the Gisholt Machine Company, Madison, Wis. The smaller size have a single swivel head and are driven by a 4 step cone pulley, giving 16 table speeds available through the head stock and two speed counter shaft. The larger machines have a total of 12 table speeeds. Any of these machines, however, may be motor driven if desired. The catalog is arranged with an excellent photograph of the machine on one page and the principal dimensions and a brief description on the facing page. It also includes illustrations showing the details of construction as well as the mills working on some locomotive parts. There are many new features on these mills that will be appreciated by the shop superintendent.

Keeping Shop Records of Belting.—The average railroad shop buys a large amount of belting each year, which is chopped up and put on various machines throughout its plant as belting gives out. Few plants keep any record of the actual length of service of the belts on any particular machine. At the end of a year's time it is not definitely known whether the belt equipment for the various kinds of machinery in the shop has cost more than it should or not. No doubt railroad shops generally will be interested in a plan of keeping shop records which have just been gotten out by the engineers of the New York Leather Belting Company, 51 Beekman street, New York City. Charts have been printed, which can be tacked up on every floor in a factory, and, by merely filling in certain blanks, entailing little or no trouble, at the end of the year, the exact record of belts on every machine on that floor can be absolutely checked up. In this age of cost reduction systems, a system of shop belt records of this sort should be kept. The belt record charts of the sort described above may be had by applying to the above company.

NOTES.

Summers Steel Car Co.—On account of the increase in its business during the last year this company announces that it has recently changed its offices to 2312 Henry W. Oliver Building, Pittsburgh, Pa.

Cleveland Twist Drill Company.—After the first of May this company will move its Chicago branch to 9 North Jefferson street, where greatly improved facilities are afforded.

Firth-Sterling Steel Co.—It is announced that A. E. Barker has been transferred from the Chicago office to Birmingham, Alabama. E. S. Jackman & Co., 710 Lake street, Chicago, are the general agents for this steel.

Flannery Bolt Company.—It is announced that George E. Howard has been appointed eastern representative for the above company, general sales agent for the Tate Flexible Staybolt, with office at Pittsburgh, Pa.

Clement Restein Company.—This company, of Philadelphia, manufacturers of Belmont packings, have opened a branch office and stock room at No. 11 Woodward avenue, Detroit, Mich., with E. N. Marcy, who was formerly connected with its general office as manager.

Burton W. Mudge & Co., Railroad Supplies.—On May 1 this company will remove its office to temporary quarters in Suite 1003, People's Gas Building, Chicago, until such time as the southern portion of the same building is completed, when it will occupy offices overlooking Michigan boulevard and Adams street.

Pressed Steel Car Company.—Frederick Mortimer Robinson, who has been connected with this company for the past six years as sales agent, died of pneumonia on April 2 and was buried in Petersburg, Va., April 4. Mr. Robinson was 33 years of age and had formerly been connected with the Chesapeake & Ohio Railway Company.

Dearborn Drug & Chemical Works.—It is announced that after May 1, 1910, the general offices and laboratory of the above company will be located on the twentieth floor of the McCormick Building, Michigan avenue and Van Buren street, Chicago. On account of the extensive growth of its business it was found necessary to remove from its present quarters in the Postal Telegraph Building.

Boston Belting Company.—The company advises that its arrangements with the Jewell Belting Co. of Chicago to act as its Western agent have been terminated and announces that it has opened a store at 177 Lake street, Chicago, with M. S. Curwen, manager of sales, in charge of the same. They will carry in Chicago an even more complete assortment of rubber belting, hose, packings and other mechanical rubber goods than in the past.

Davis Bournonville Company.—This company, of 90 West street, New York, announces that the Ohio Welding & Mfg. Co., 828 West Sixth street, Cincinnati, Ohio, will act as its dealers. With this in view a large demonstrating plant has been installed, including not only the welding equipment, but also the oxygen plant. The repair work will include everything to which the oxy-acetylene process can be applied. This company will also shortly open a demonstrating and repair shop at 2121 East Second street, Cleveland, Ohio.

RAILROAD SHOP LAYOUTS

A DISCUSSION OF THE FEATURES THAT INFLUENCE THE RELATIVE LOCATION OF THE STRUCTURES THAT MAKE UP AN AVERAGE RAILROAD SHOP PLANT.

F. Kingsley.

The arrangement of the buildings comprising a complete railroad repair shop is a matter subject almost entirely to convenience in the handling of material. There are, of course, other considerations, but, in the main, if it were not for the difficulty and cost of transporting the vast number of parts entering into the construction of locomotives and cars, between the various shops, any arrangement of buildings would be satisfactory.

Manifestly, in cases where the shop site is restricted in size, conditions may arise whereby the desirability of convenient arrangement must be sacrificed to the necessity of getting all of the buildings into the space provided. However, such cases occur only where policy demands the retention of a shop within a large city where the cost of real estate is high, and present practice shows a decided trend away from the custom of loading shop costs with a heavy surcharge on account of excessive ground values. In the great majority of cases, when new shops are proposed, the ground area is, within reasonable bounds, unlimited.

In such cases of unrestricted area, similarity of practice on American railroads would point toward the possibility of a single ideal arrangement, unaffected by ordinary differences in conditions, and applicable in every case. Material handled between the various departments and buildings is much the same in character and relative quantity for every railroad shop in the country; and for this reason each new railroad shop can hardly be considered as an entirely new problem with characteristics materially different from shops already in existence. Existing shop arrangements, however, indicate that there is no tendency toward uniformity. It is safe to say that there are not half a dozen shops in the country having marked similarity of arrangement. Nevertheless, every shop layout is affected by the same set of general rules which are so well known, in fact, so self evident, as to be practically axiomatic.

There is, or should be, a sound reason for everything that is done. Advocating the application of perfectly obvious common sense rules to shop layouts may seem superfluous; but, on the other hand, many obvious truths about shop layouts are often neglected. For example, it would be difficult to find an argument against placing the storehouse and machine shop near together. A great deal of material in small lots is continually passing between the two buildings, especially where any manufacturing of standard pieces goes on. The desirability of adjacent locations is manifest, yet in a certain new shop, splendidly built and thoroughly organized, the storehouse is separated from the machine shop by a transfer table. Naturally, this results in a large and cumbersome sub-store in the machine shop, requiring double handling and charging of much material and occupying valuable floor space. The transfer table in front of the blank storehouse wall is exactly comparable to the proverbial fifth wheel on a wagon.

Another case of divergence from a perfectly obvious rule is found in another modern shop where the power house and the blacksmith shop are at extreme opposite sides of the group of buildings. The primary result has been that the pipe tunnel required for the live steam line to the steam hammers has alone cost as much as a good sized building, to say nothing of the cost of the pipe and the continuous loss due to condensation. At the same shop the storehouse is found so close to the power house as to constitute a bad fire risk, and yet if there is any pair of buildings which can be separated without sacrificing efficiency it is the store and the power house. The power house requires stores not even semi-occasionally, while the storehouse needs power only for lighting and possibly elevators, and only a small amount of steam for heating. Such examples can be multiplied indefinitely.

In general, every repair shop may be considered as having three departments—locomotive, coach and freight car. There is also, in every case, a power house, a storehouse, a blacksmith shop, a planing mill; and, in some cases, a wheel shop and also an iron foundry. For the purpose of citing the most obvious of the rules affecting the arrangement of buildings, the main departments will each be considered with relation to the various subdepartments, namely, the blacksmith shop, machine shop, planing mill, power house, and storehouse.

Taking up, first, the freight car department, it is, in most cases, a repair department only; and even is very likely to be composed merely of repair tracks for bad order cars. The number of cars handled, however, makes it an important consideration. As it is probable that fifty cars are switched onto the rip-tracks for every locomotive set into the erecting shop, it is safe to say that the freight car department should be placed adjacent to the main line, even at the expense of the locomotives and coaches. By reducing the length of switching movements, considerable time, trouble and even confusion, can be avoided.

Blacksmith shop work for this department is of evident importance. A vast amount of small blacksmith work has to be done for the car repairers, and this should make it imperative that the blacksmith shop be near; in fact, adjacent to the repair tracks, unless one is sufficiently reactionary to duplicate facilities.

Machine work for the department, excepting wheels, is not large in amount and is, in any event, rough. If a separate wheel shop building is put up, it is safe to say that it must be adjacent to the repair tracks, but in a plant too small to warrant a separate wheel shop building, and requiring machine work to be done in the locomotive machine shop, it is not necessarily axiomatic that the machine shop be adjacent to the repair tracks. Mounted wheels with good industrial track facilities are quite easily transported.

Planing mill work for the freight car department is, of course, of absolutely primary importance. In a shop so large as to permit passing lumber through the planing mill in large lots to be held till needed in the finished lumber store, the necessity for locating the mill adjacent to the rip-tracks is not so much in evidence. However, in any event the finished lumber store must be convenient to the repair tracks, preferably adjacent to the freight car repair shop building, where one exists, on account of the greater probability of heavy work being there, rather than on the repair tracks.

The power house is manifestly an unimportant factor of the department. No power except air is used, and no steam for heating the repair tracks is necessary.

Stores for the department are not widely diverse in character and sub-stores seem to be the rule at present. However, the quantity of material going from the storehouse to the department, especially to the freight car shop, is very large, and for all purchased material at least, if the storehouse is not adjacent to the freight car department, it necessitates double handling and, in fact, unnecessary duplication of facilities all around. It

is safe to say, therefore, that the storehouse should be adjacent to the freight car shop and as convenient as possible to the entire length of repair tracks.

The coach department is of necessity a rather minor one. The number of coaches on the average road is relatively small, and this, combined with the class of work done on the coaches while in the shop, reduces the importance of the department in regard to its relative location.

Blacksmith work is required in a fair amount, and consequently the blacksmith shop should, if permissible for a minor department, be located near the coach repair shop.

Machine work, excepting wheels, is required only in small amount. Tire work is, of course, very heavy relatively. If a separate wheel shop building is considered it should be adjacent to the coach shop, but the same argument applies here regarding wheels as in the case of the freight department.

Planing mill work, and especially cabinet shop work, is of vital importance, although the quantity of material is smaller than in the case of the freight car shop, and a positive rule can be safely made that the planing mill and coach shop should be adjacent.

Stores for the department are generally small in quantity and and practically all castings have to be machined. Where manufacturing is done this necessity is even greater on account of the double movement between the two buildings.

Power is important and the power house should be adjacent to the locomotive shop, not only on account of the amount of power used, but also on account of the desirability of reducing the length of the pipe tunnel for live and exhaust steam and air piping between the two buildings.

The relations of the three main departments with each other are, as before mentioned, unimportant, except in the cases where the wheel shop machinery is located in the locomotive machine shop.

Of the sub-departments not covered by the foregoing, the power house may be said to necessarily be near to the locomotive shop, the blacksmith shop and the round house on account of the very large amounts of steam required in these buildings. It should also be within 250 feet, or preferably 200 feet, of the planing mill, on account of the high cost and mechanical difficulty of blowing shavings from the mill to the power house boilers when the distance is great. The coach shop, freight car shop, wheel shop, storehouse and foundry need but little steam and need not be near the power house.

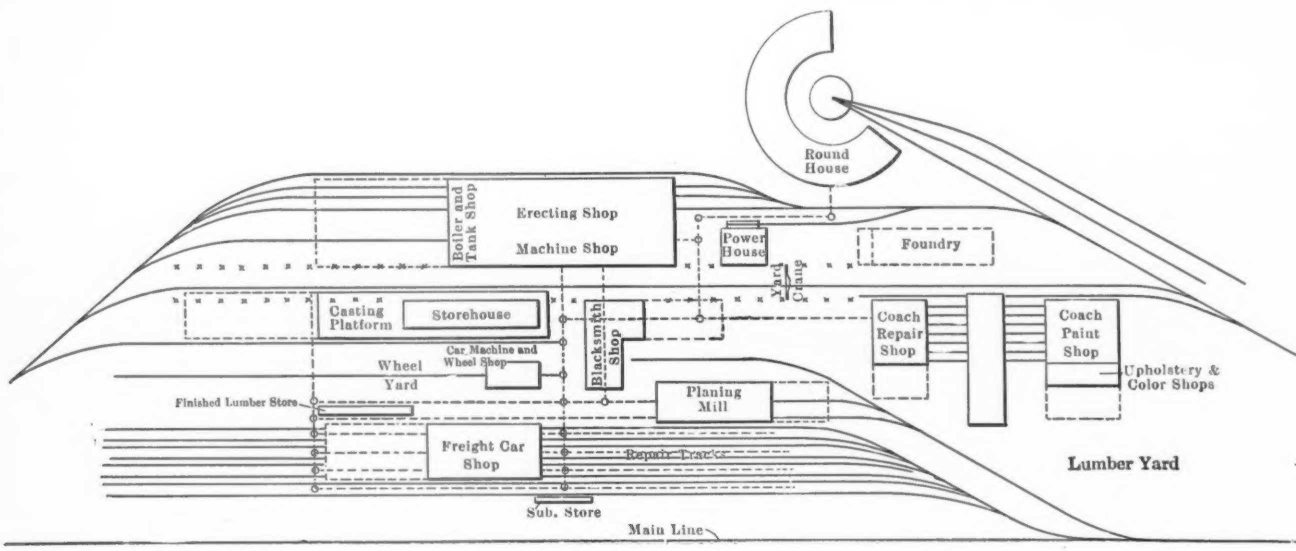


FIG. 1.

need not be considered of great importance. Power is also practically negligible.

This brings the matter up to the consideration of the locomotive department. In this there is a very strong and decided tendency toward having the erecting, machine and boiler shops in one building. This practice is backed by the very sound reason that boilers of to-day absolutely require crane service, and by extending the erecting shop this service can be obtained from cranes which have to be furnished for the erecting shop in any case. The small extra cost of having the boiler shop and machine shop of the same height is more than balanced by the advantage of being able to take boilers off their frames and set them in the boiler shop, without putting them on trucks or even changing hitches. Tank work is necessarily done in the boiler shop on account of similarity of labor.

Blacksmith shop work for the locomotive department is, of course, of more importance than is found in any other department relation. Manifestly the blacksmith shop must be adjacent to the machine or erecting shop, preferably the former, as the distance of transportation of material is somewhat less, and the convenience greater.

The machine shop is, in every case, a part of the main locomotive shop.

Planing mill work is so small in quantity and is decreasing so steadily as to be negligible.

The storehouse must necessarily be adjacent to the machine shop, as the casting platform is usually a part of the storehouse

The planing mill need be near only the freight car shop, adjacent to the coach shop and repair tracks and within 250 feet of the power house. At one end of the mill should be space for storage of a large amount of rough lumber, and at the other end should be the finished lumber store, so that lumber can go through the mill without any retrograde movements even outside. The dry kiln, when installed, must, of course, be between the lumber yard and the planing mill.

The round house, whether a small one used only for breaking in engines, or a large one for regular terminal work, should, if possible, be near the power house, as before stated. It should also be near the machine and blacksmith shops, on account of the considerable amount of these classes of work often done for the round house. The approach tracks should be long and straight to permit easy storage and movement of engines under steam, and also to give ample room for coal and ash handling facilities.

The wheel shop, when installed, should be adjacent to all three main departments. This is probably an impossible condition and the freight car department takes precedence over the coach shop and locomotive departments. This would give a location adjacent to the freight car shop.

The iron foundry is strictly a manufacturing shop with a given daily output which can be handled in large lots on trucks. This permits its location at any point in the shop yard where ample room can be left around it for the storage of flasks, coke and iron.

Yard cranes, when installed, should serve as many buildings as possible. A saving will also be effected by supporting the crane runway on building walls rather than providing separate steel columns, and this would make it advisable to locate the crane over the longest passageway between buildings which exists in the shop layout.

The proper distance between buildings which avoids bad fire risks cannot be definitely fixed. However, experience has shown that seventy-five feet is the practical minimum, and under no circumstances should main buildings be placed less than fifty feet apart.

Naturally in the foregoing list of desirable conditions there are several which are contradictory. It is, for instance, a probable impossibility to locate both the storehouse and blacksmith shop adjacent to all three of the main departments. The necessity for providing space for extension of all buildings also involves conditions which increase the difficulty of finding an entirely satisfactory arrangement. In consequence it is certain that arrangements will always vary in accordance with individual ideas as to which departments should be favored. Figures 1 and 2 show arrangements embodying most of the desired conditions. The two are exactly the same scheme, except that Figure 1 shows a longitudinal erecting shop and a transverse coach shop, while Figure 2 shows a transverse, lift over, erecting shop and a longitudinal coach shop, the latter being possibly more desirable for very small shops.

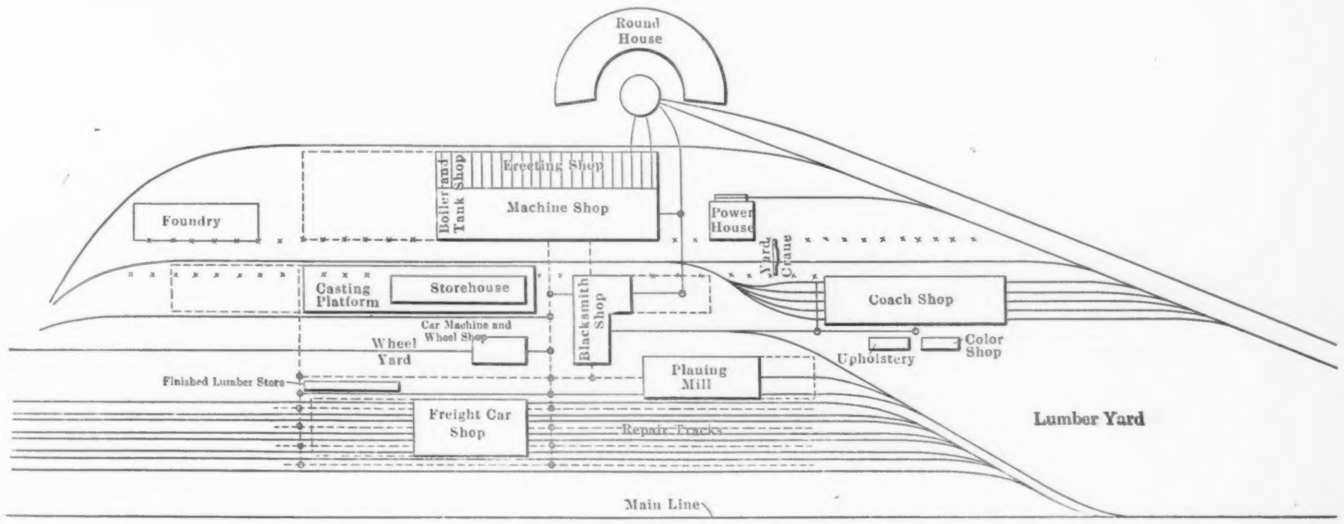


FIG. 2.

The most evident weak feature of these layouts lies in the distance of the coach shop from the wheel shop. The fact that the wheel shop is not on the line of the yard crane is another undesirable feature, provided, of course, that a yard crane is installed. These are both the outcome of favoring the most important department.

Summed up, it may be said that the following considerations govern any shop arrangement, provided ground area is not restricted, or the track system prearranged:

Freight repair tracks and freight car shop near to main line.

Finished lumber store adjacent to freight car shop.

Planing mill between lumber yard and finished lumber store and adjacent to repair tracks.

Coach repair shop adjacent to planing mill and near wheel shop.

Storehouse adjacent to freight car shop and to machine shop.

Blacksmith shop adjacent to freight car shop and machine shop, also adjacent to car-machine and wheel shop when one is installed.

Wheel shop adjacent to all departments, but especially to the freight car shop.

Machine shop adjacent to storehouse, blacksmith shop and power house, also to round house, when possible.

Power house adjacent to blacksmith shop, machine shop and round house, and not over 250 feet from the planing mill.

In conclusion, the question may arise as to how much ground area is required for the proper construction of a complete set of shops. This may be very roughly determined by using a figure of from 2 to 3 acres per pit in the erecting shop. These figures are based on existing arrangements, the former requiring a decidedly compact arrangement of buildings. It is, of course, a practical impossibility to have too much ground for a shop, especially in view of the future extensions, which are absolutely certain to eventually become necessary.

CONVENTION OF THE TRAVELING ENGINEERS' ASSOCIATION.

The Eighteenth Annual Convention of the Traveling Engineers' Association will be held at the Clifton Hotel, Niagara Falls, Canada, commencing at 10 A. M., Aug. 16, 1910, and continuing four days.

Following is list of subjects to be discussed at this meeting:

1.—Fuel economy, under the following heads:

(a) Value of present draft appliances. Can they be improved to effect fuel economy?
(b) Firing practices, including the prevention of black smoke.
(c) Roundhouse practices; whether it is more economical to knock or bank fires at terminals.
(d) Whether it is more economical to buy a cheap fuel of a low heat value, or a higher priced fuel of a greater heat value.
(e) Devices and appliances for use on engines and tenders to prevent waste en route.

2.—Superheat as applied to locomotives.

3.—How can the traveling engineer best educate the present day fireman to become the successful engineer of the future?

4.—Latest developments in air brake equipment and its effect on train handling.

5.—What progress has been made in reducing the cost of locomotive lubrication, and is it advisable to place this item entirely under the control of the road foreman or traveling engineer?

6.—New valve gears as compared with Stephenson or link motion, referring particularly to economy of operation and maintenance, and also necessary procedure in case of breakdowns.

Apprentice School.—We inaugurated an apprentice school on our road about six months ago. When it was first suggested some of the men said we did not have the facilities, but we made them. We took two box cars, put them together, and put windows in them, and you would be surprised at the results we are getting from the apprentice boys that started in the school six months ago. They are all students. There should be more students among the mechanical men.—*F. C. Pickard at the General Foremen's Convention.*

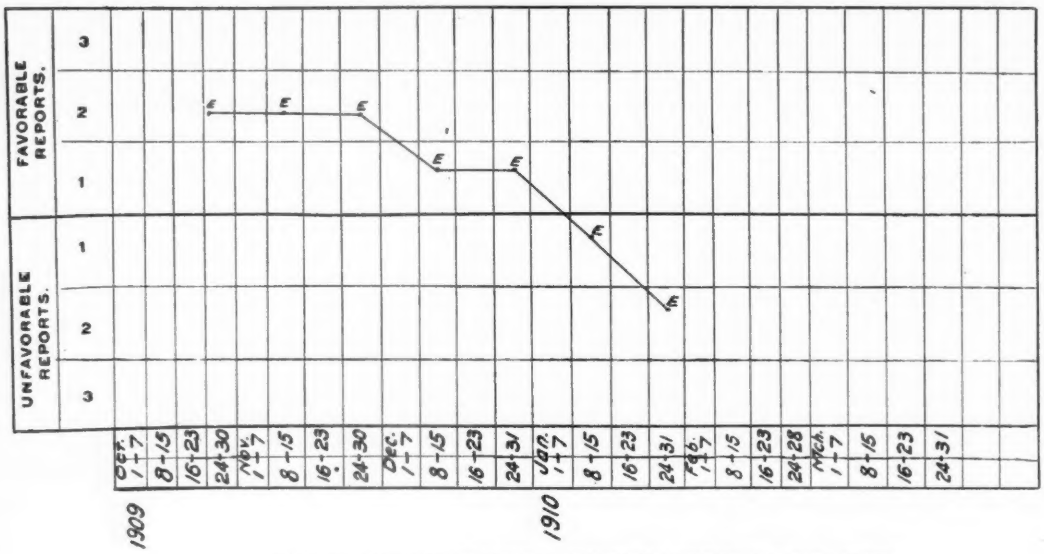
CANADIAN PACIFIC RAILWAY.
MOTIVE POWER DRAWING OFFICE.

RECORD OF TEST NO. 50 ON Piston Rod Lubricator

Applied to engine 1191 , Eastern Division, Oct. 10 1909 ; Reports expected every two weeks
" " 866 , " Division, " 30 1909 ; Reports expected " " "
" " ______ , ______ " ______ 19 ______ , Reports expected ______
" " ______ , ______ " ______ 19 ______ ; Reports expected ______
" " ______ , ______ " ______ 19 ______ , Reports expected ______
" " ______ , ______ " ______ 19 ______ , Reports expected ______

Authority for test Supt. Motive Power, letter Oct. 1st 1909 Final report to be sent to Asst. to Vice President & Supt. Motive Power

Remarks as to application This lubricator is intended to oil the piston rods and works as a displacement lubricator when throttle is open, and as a syphon oil cup when throttle is closed. It must be shut off when engine is standing.



FACE OF CARD FOR KEEPING A GRAPHICAL RECORD OF ROAD TESTS.

SUMMARY OF REPORTS.

Oct. 25th lubricator on 1191 oiling rod satisfactorily, engineer reports more satisfactory than swabs
Nov. 12th lubricators on 1191 & 866 satisfactory, same condition as previous reports
" 27th " " " " " " " " " "
Dec. 12th considerable oil being used
" 28th " " " "
Jan. 10th entirely too much oil being used, when engine is drifting and cup is working as syphon all oil is drawn out in a short distance
Jan 28th lubricator becomes in operative in cold weather owing to fine feed which is necessary

RECOMMENDATIONS.

TEST CLOSED Feb. 1. 1910 RESULT Owing to construction of lubricator it was difficult to apply to existing cylinder heads, it used excessive amounts of oil and froze up in cold weather.

Papers filed in Test Fyle, T50.

REVERSE OF CARD FOR KEEPING A GRAPHICAL RECORD OF ROAD TESTS.

A GRAPHICAL RECORD FOR ROAD TESTS.

G. I. EVANS.

A great many railroads, from time to time, test some of the numerous devices put on the market for use on locomotives and cars. Such devices are generally not amenable to laboratory tests, and must be put into actual service before any idea can be obtained as to their usefulness, and, as one or more may be applied on different locomotives running on different divisions of a railroad, and may be in service any length of time from one to twelve months or more, and, as results are noted and reported by master mechanics and other operating officials, considerable correspondence accumulates before any definite conclusions may be arrived at.

Given a sufficient number of such tests, a man will spend much more of his time than he can spare in wading through files of correspondence, trying to get an idea how matters stand, and having just this condition, the writer, some time ago, devised the combined record and chart which is shown in the illustration as a convenient way for following up road tests. The record is kept on letter size cards (8⅛ in. by 10¼ in.) outlined as shown, and are printed on both sides. These cards are filed apart from the correspondence, consecutively, in a vertical file, and as they take up but small space, a large number can be retained in the file, forming a permanent record of all tests made. The correspondence file, which is bulky, is regularly weeded out and all closed tests are removed to the storage file.

The first portion of the card gives a complete record of the application of the device, when reports are to be sent in, and to whom the final report is to be submitted, while the chart shows at a glance how these instructions are being carried out, and what results are being obtained.

The chart is divided into two main horizontal sections, the one above the heavy line is for reports favorable to the device under test and the lower for those unfavorable; each of these main divisions is again subdivided into three sections, each of which represents a degree of excellence or unsuitableness as compared with some standard which has been previously assumed, thus, a report may be received saying that a certain device is giving as satisfactory service as the one which it is intended to supersede. This would naturally be a No. 1 favorable, but if the report had shown that the performance was slightly better than the standard, it would be a No. 2 favorable, etc. Unfavorable reports are recorded in a similar manner, slightly inferior to the standard constituting a No. 1 unfavorable, etc. When entering the report a dot is made opposite the month in such a position as to represent approximately the date received and the curve is drawn through these points, a letter representing the division is placed close to the dot showing from where the report came. By noticing whether the dates on which the reports are received correspond with the dates on which they are expected, a check can be kept on who is behind with reports.

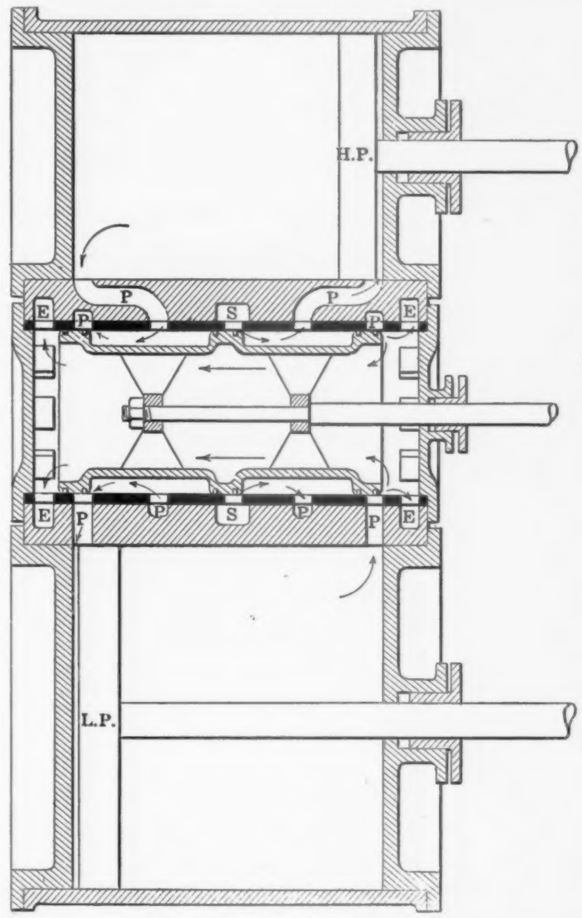
On the back of the card is a short summary of each report received, and finally the date on which the test was closed and the recommendations made as to the advisability of adopting the device.

PISTON VALVE FOR BALANCE COMPOUND LOCOMOTIVE.

M. W. DAVIDSON.

The accompanying illustration shows a proposed design of piston valve for balanced compound locomotives worked out by the writer, which appears to possess some points of advantage over other types of this valve with which he is familiar.

The sketch is not drawn to represent an actual design of this valve, but merely to show in general its construction and operation. The cavity surrounding the valve and marked S contains live steam from the boiler, the two marked E, one at each end, being the exhaust ports to the atmosphere, those marked P are the ports to the cylinders, as may be clearly seen. In the dead center position shown, the high pressure piston is receiving steam on the crank side while the steam from the opposite side of that piston is exhausting into the low-pressure cylinder, head end, also the steam from the crank end of the low pressure cylinder is exhausting into the atmosphere through both exhaust passages E, if the valve is made hollow, as is shown in the illustration.



At first glance, objection might be made to this valve on account of the clearance it gives to the high-pressure cylinder; however, the incoming steam to this cylinder always finds this space full of steam compressed almost to boiler pressure; also, this clearance volume, which is really a part of the passage to the low pressure cylinder, being full of steam when the valve opens to the low pressure piston, the drop in pressure between the high and low pressure cylinders is small.

This valve also possesses the advantage of simplicity of construction and few parts, only six rings being required, as against twelve on one well known valve designed for similar use. The steam and exhaust cavities are much simplified as well.

COMBINATION BUFFET AND BAGGAGE CAR.

There was recently turned out of the West Albany shops of the New York Central & Hudson River Railroad, combination baggage and buffet car No. 473, which as is evident from the accompanying view of the interior and floor plan, is most attractively finished and conveniently arranged. The car has a length of 70 ft. over end sills, the baggage compartment occupying 22 ft. 1½ in. at one end and the passenger compartment 35 ft. 2 in. of the other end, between these being located the pantry and barber shop.

In the passenger compartment there are 18 movable mahogany chairs beautifully upholstered in green leather and two Pullman seats, giving a seating capacity of 26 passengers. The arrangement includes a bath room, very ingeniously located so as to occupy the minimum of useful space. It contains a shower bath and is entered from the barber shop. The barber shop section is much larger than customary, and has light from both sides

COMBINATION BAGGAGE AND BUFFET CAR—NEW YORK CENTRAL LINES.

of the car. The barber shop, bath room and pantry combined occupy but 12 ft. and each is amply large. The arrangement of the toilet room at the end of the car has also been very ingeniously worked out to give maximum facility in a minimum room.

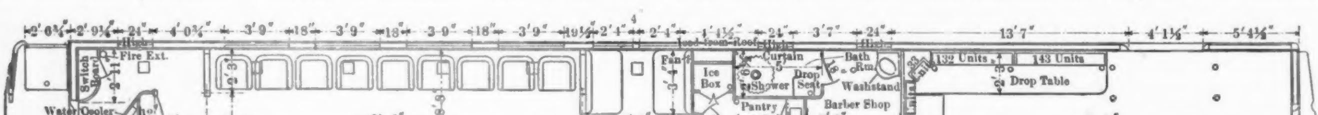
The square, beamed ceiling fitted with concealed lights in attractive fixtures, is used in the smoking compartment. The finish is severely plain so far as the woodwork is concerned but is relieved of all monotony by the lighting fixtures underneath the deck and the art glass ventilators. The seats are of heavy polished mahogany design that is in keeping with the interior finish of the car, which is also of polished mahogany. Electric lights are of course used throughout the car, and several fans are also provided. Current is obtained from a 60-volt Gould battery. The total number of lights in the car is 43.

In the baggage compartment are cases for distributing mail to the number of 429, with convenient tables which can be dropped down out of the way when not in use. The underframe is of steel throughout and the car is carried on standard 6-wheel wooden trucks.

Among the specialties are the following: Miner spring draft rigging; Westinghouse type L brakes; Waycott brake beams; Commonwealth steel platforms; Tower coupler; Ward vapor steam heat; Garland ventilators; Chaffee centering device; Edwards window fixtures and steel trap doors; and Taylor oil boxes.

VIEW SHOWING THE HANDSOME INTERIOR OF THE SMOKING ROOM.

This car has a total weight of 136,700 lbs. and measures 75 ft. 6 in. in length over all. The journals are 5 x 9 M. C. B. standard



FLOOR PLAN OF COMBINATION CAR—NEW YORK CENTRAL LINES.

VERY POWERFUL ARTICULATED COMPOUND LOCOMOTIVE

A GENERAL DESCRIPTION OF A DESIGN FROM WHICH THE AMERICAN LOCOMOTIVE COMPANY HAS BUILT SIX LOCOMOTIVES FOR THE DELAWARE & HUDSON COMPANY TO OPERATE ON A GRADE BETWEEN CARBONDALE AND ARARAT, PA., WHERE THE RULING GRADE IS 1.36 PER CENT. AND CURVES ARE NUMEROUS.

Out of Carbondale, Pa., northward, the Delaware & Hudson Company operate a large number of solid coal trains that normally have a tonnage of about 2,600. Between this point and Forest City there is a continuous grade of 1.36 per cent., then follows a grade of .81 per cent. for the next 14 miles, ending at Ararat. This is the summit of the rise, and from here into Oneonta, N. Y., is a down grade of averaging 1 per cent. for the 75 miles. The loaded traffic is practically all north bound and a 2,600 ton train is placed behind a class E-5 consolidation locomotive,* which will handle it very satisfactorily on the down grade from Ararat to Oneonta, but from Carbondale to Ararat it is necessary to put two locomotives of the same class behind the train as pushers. With this motive power a speed of ten miles per hour can be maintained for the first six miles and of 15 miles per hour for the next 14. The class E-5 locomotives have a total weight of 246,500 lbs., of which 217,500 is on drivers. The tractive effort is 49,690, the cylinders being 23 by 30 in.; drivers, 57 in., and steam pressure, 210 lbs.

It is evident that this section of the road is of a character particularly well suited for the Mallet Articulated compound type of locomotive and with the idea of determining what advantages that type possessed under these conditions, the Delaware & Hudson Company borrowed from the Erie Railroad one of its Mallet locomotives and made a number of test runs. The Erie engine easily did the work of the two class E-5 pushers and the result of the test was the placing of an order with the American Locomotive Company for six engines of the design illustrated herewith.

This design, while considerably larger than the Erie engines, is but slightly modified from that arrangement or from the other articulated locomotives built by this company in smaller sizes. The wheel arrangement is of the 0-8-8-0 type and is arranged to give about ten per cent. more power than the Erie engine, the weight being increased about 35,000 lbs. over that arrangement. In working order they have a total weight of 445,000 pounds, all of which is carried on the driving wheels. The high pressure cylinders are 26 in. in diameter by 28 in. stroke, and the low pressure cylinders are 41 in. in diameter by the same stroke. With the boiler pressure of 220 pounds and driving wheels 51 in. in diameter, the theoretical maximum tractive effort, working compound, is 105,000 pounds. With the Mellin system of compounding employed, the normal maximum tractive effort working compound can be increased about 20 per cent. by changing the engine into simple. The maximum tractive effort of these engines working simple is thus 126,000 pounds.

With the same average weight per driving axle and a rigid wheel base 2 feet 3 inches shorter, these articulated locomotives, thus, under normal working conditions, have over twice the power of the Class E-5 consolidation locomotives, and in case of emergency can exert a tractive effort more than two and one-half times as great as the latter.

One of these engines as a pusher and a Class E-5 locomotive in the lead, will easily take a 2,600 ton train up the grade, where it previously took three Class E-5 locomotives. The six articulated locomotives in this order will, therefore, relieve 12 of the consolidations from this service without sacrificing any tonnage, and with a saving in operating expenses due to handling less units.

Apart from the increase in size and power, the principal changes in the design from that of the Erie engines† are a different arrangement of high pressure steam pipes, and the location of the cab over the fire box.

Owing to the large diameter of the boiler, it was necessary in this instance to locate the high pressure steam pipes underneath the running boards, as shown in the illustration of the side elevation. Steam is led from the throttle through a dry pipe to the smoke box, where it is divided in a tee-head and passes into two branch pipes, one in either side of the smoke box, in the same manner as in a single expansion engine. From these branch pipes, to which they are connected through elbows with ball joints, two wrought iron steam pipes extend back underneath the running board, on either side of the boiler, to the high pressure cylinders. An elbow covers the steam passage to the cylinders, to which the steam pipe is joined by means of a specially designed connection having a ball joint at either end and fitted with a slip joint. This construction permits of the expansion and contraction of the steam pipe, due to variations in temperature, and also facilitates removing and putting it up when repairs are necessary.

With this arrangement of steam pipes, the engineman is afforded a comparatively unobstructed view ahead.

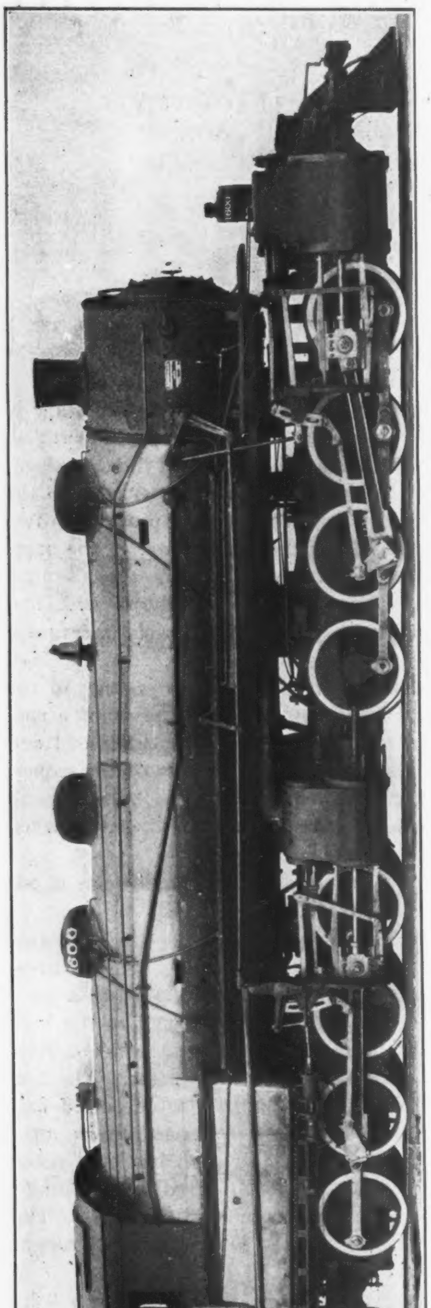
The design of the cylinders is, in general, the same as used on previous Mallets built by the same company. The low pressure cylinders are the largest in diameter ever applied to a locomotive, being 41 in. by 28 in. Steam is distributed to the high pressure cylinders by 14 in. piston valves having inside admission and ample port area to meet the requirements. The low pressure cylinders are equipped with Mellin double ported balanced slide valves which have been used successfully on previous articulated locomotives. Special provision has been made for strengthening the valve yoke. This is stayed by two longitudinal bolts passing through cored passages in the valve. The bolts are one inch in diameter and fitted with one inch wrought iron pipe thimbles, which act as spacers.

The valve gear is of the Walschaert type and is reversed by a hydro-pneumatic reversing gear. A slight modification from the arrangement of this gear as applied to previous engines of the articulated type has been made. This consists first in connecting the piston rod of the reversing engine to a downward extension of the arm on the main reverse shaft, instead of to the main reverse lever itself. Also, the handle of the main reverse lever which ordinarily projects above the deck of the cab is in this instance cut off, thus providing more room in the cab. A separate handle for the main reverse lever is provided, which can be easily applied in case it is necessary to operate the lever by hand in case of an accident to the power gear.

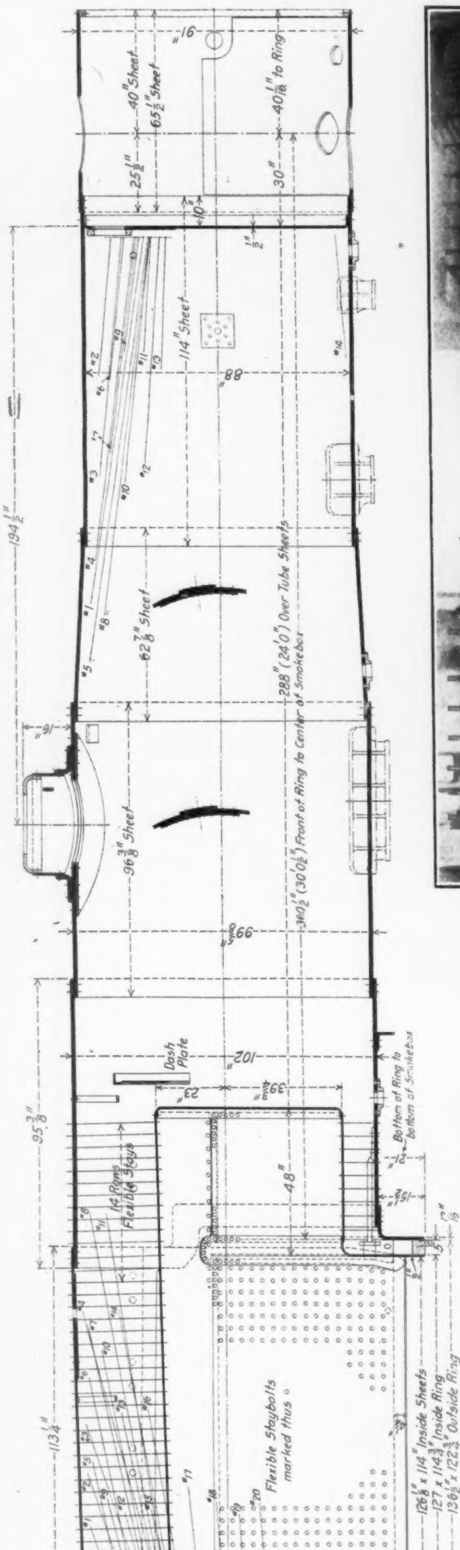
The frames throughout are of vanadium cast steel and of large section. The frames of the rear engines have a single front rail cast integral with the main frame, while those of the front system are provided with double front rails, the lower one of which is in one casting with the main frame. Both sets of frames are 5½ in. in width throughout, except that portion of the lower front rails of the front set which is underneath the cylinders. This portion is reduced to 3¼ in. in width, and reinforced by an auxiliary rail 4 in. wide, bolted to the inside of the lower rail and extending the full length of the cylinders. Over the pedestals, the upper rails of the main frames are 6½ in. deep, while between pedestals the depth of section is 5 in.,

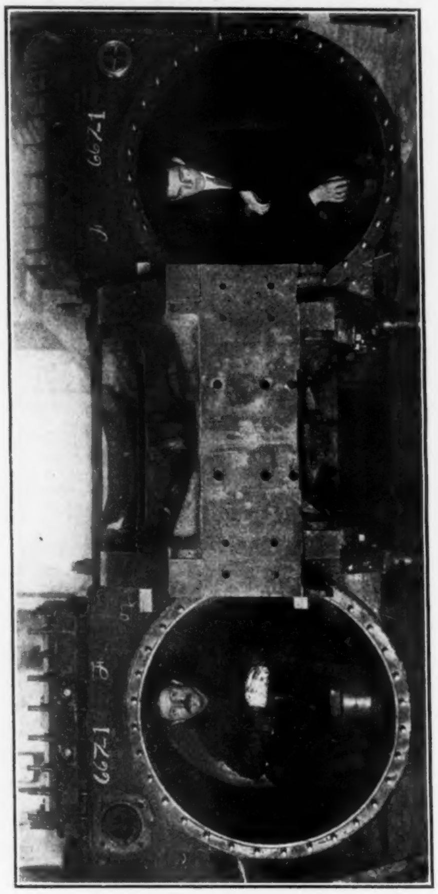
* See AMERICAN ENGINEER, January, 1907, page 22.

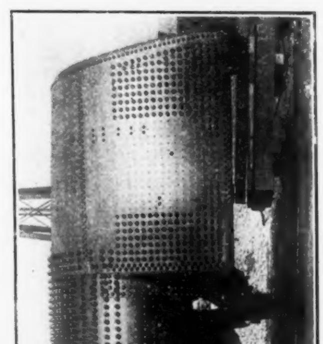
† See AMERICAN ENGINEER, Sept., 1907, page 338.



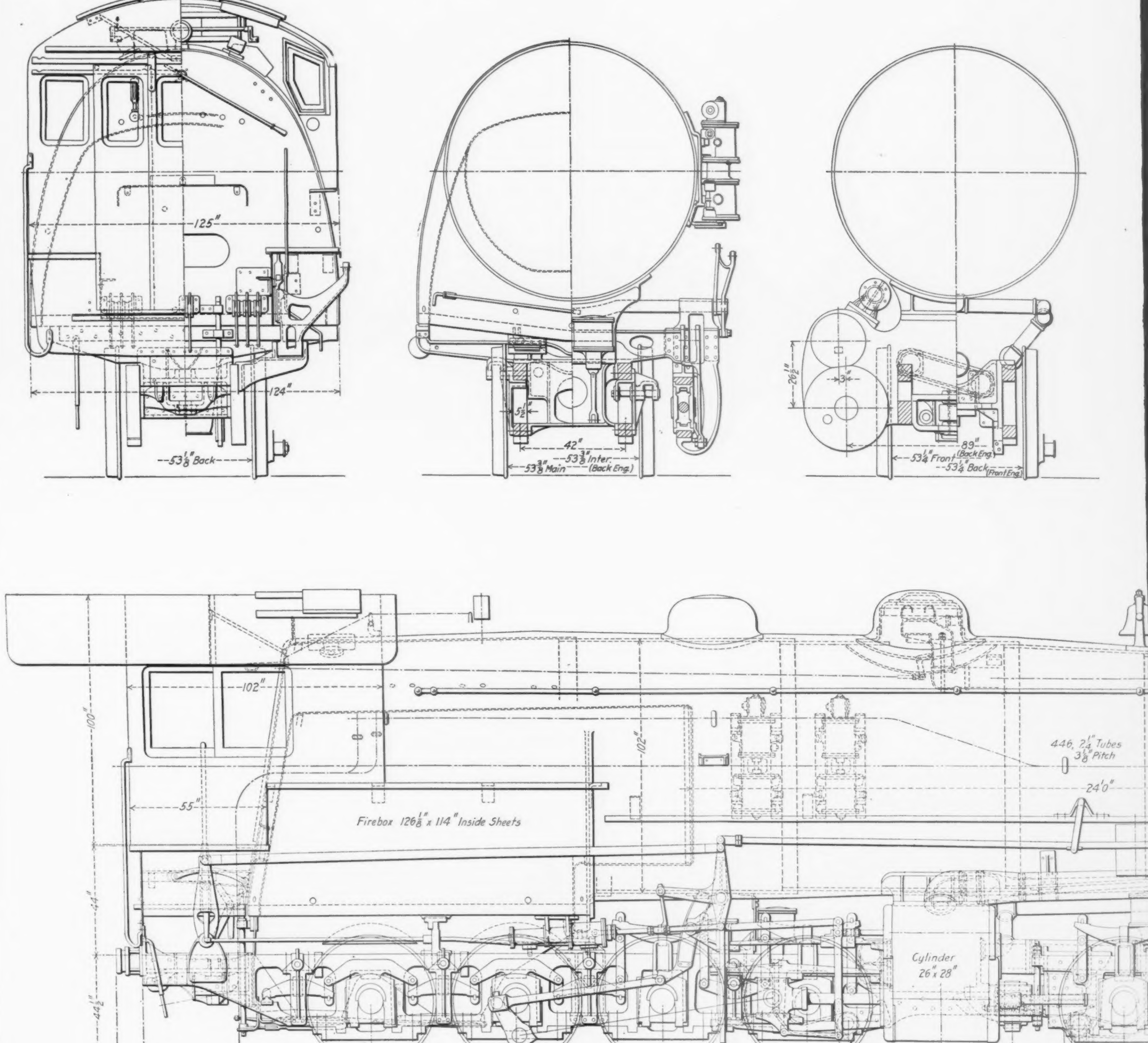
0-8-8-0 TYPE LOCOMOTIVE FOR THE D. & H. CO. THIS LOCOMOTIVE HAS 24-FT. TUBES AND A MAXIMUM TRACTIVE EFFORT OF 126,000 LBS.



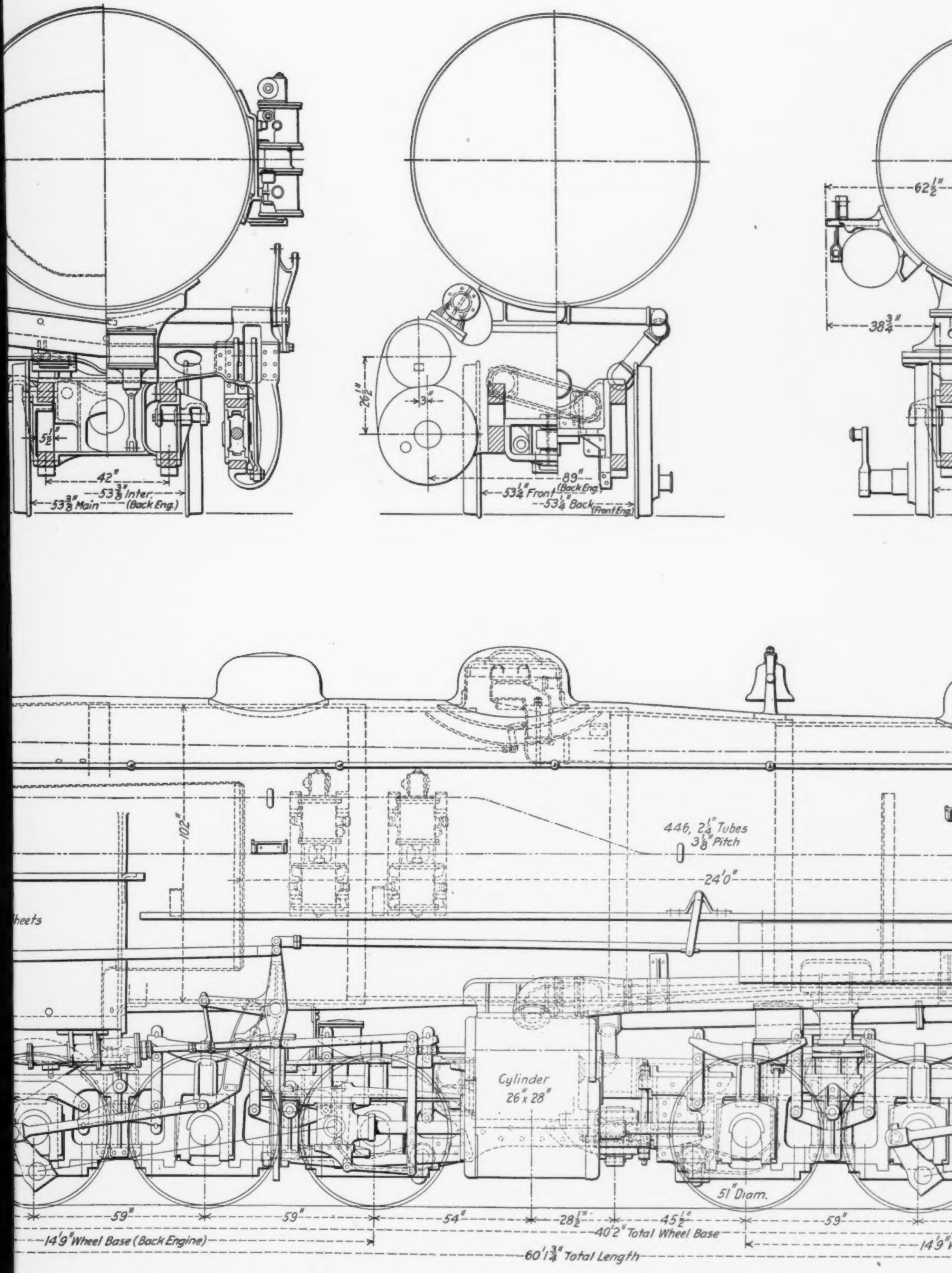




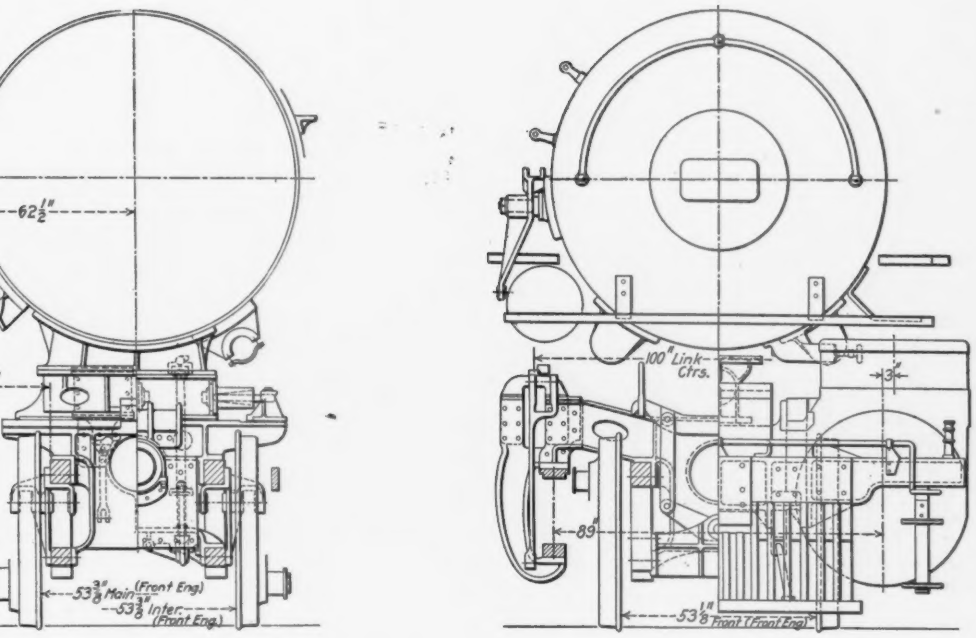
SECTIONAL ELEVATION AND VIEW OF THE VERY LARGE BOILER APPLIED TO THE ABOVE LOCOMOTIVE; ALSO VIEW OF THE 41-INCH LOW-PRESSURE CYLINDERS.



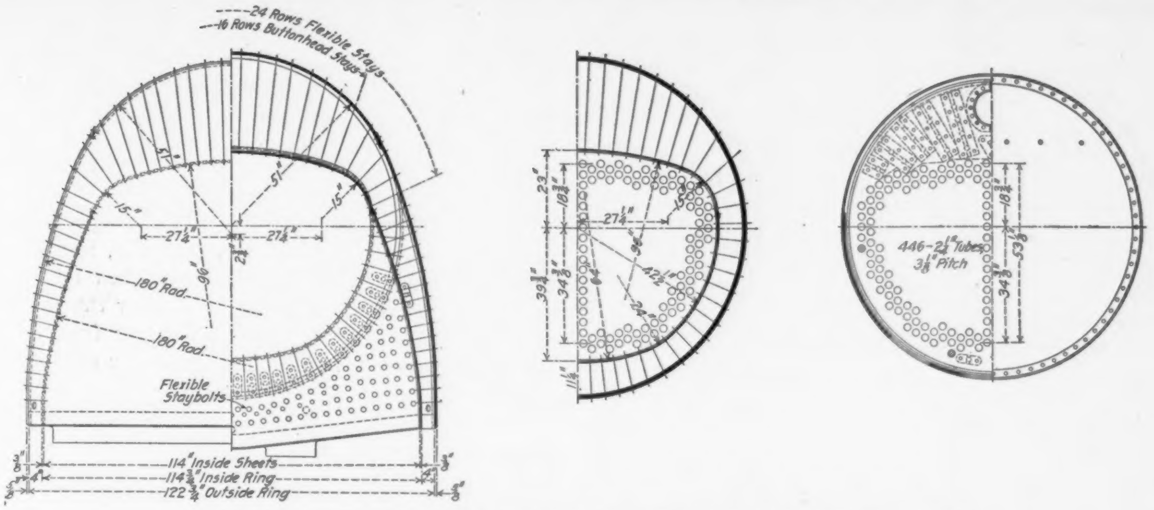
MALLET ARTICULATED LOCOMOTIVE, 0-8-8-0 TYPE, HAVING A MAXIMUM TRACTIVE EFFORT OF 126,000 POUNDS, BUILT FOR THE DELA



E, 0-8-8-0 TYPE, HAVING A MAXIMUM TRACTIVE EFFORT OF 126,000 POUNDS, BUILT FOR THE DELAWARE AND HUDSON CO



SON COMPANY BY THE AMERICAN LOCOMOTIVE COMPANY.



SECTIONS OF THE VERY LARGE BOILER ON THE DELAWARE AND HUDSON MALLET.

except at those points where the equalizing beam fulcrum castings are introduced. The bottom rails of the frames are in the main 4¾ in. deep.

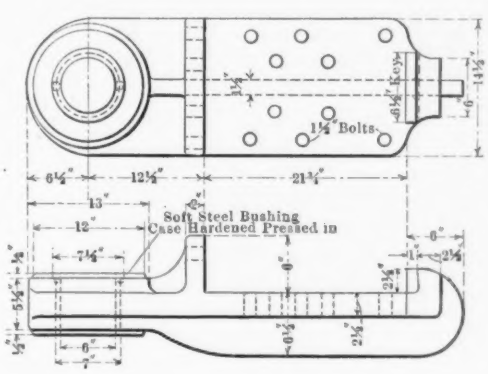
A single articulated connection is used between the front and rear systems. This is formed by a cast steel radius arm rigidly bolted to a cast steel crosstie between the rear ends of the front frames. This radius arm fits in a steel pocket casting securely bolted to the bottom rails of the rear frames, and also extends back underneath the high pressure cylinder saddle, to which it is bolted. The coupling is made by means of a vertical pin 6 in. in diameter, inserted from the top.

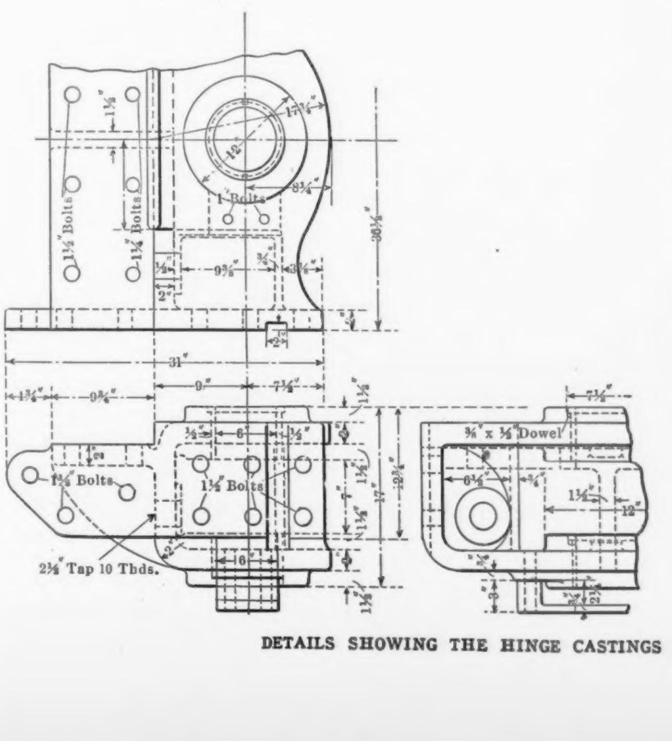
This gives a very strong and substantial connection between the two engines, and at the same time the use of the single articulated connection permits of the vertical movement of the two frames relative to each other, without any binding in the joint.

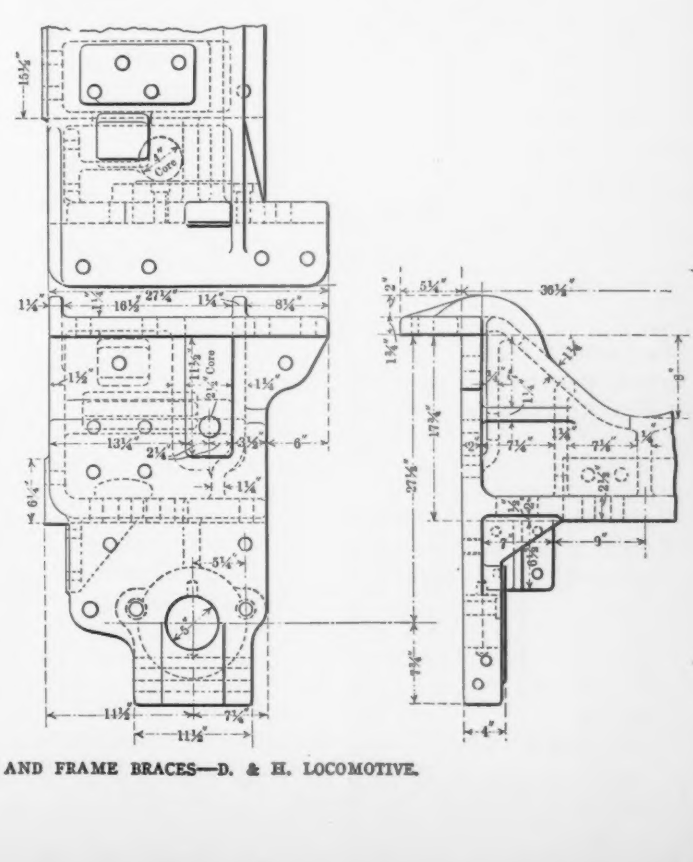
An exceptionally strong and substantial system of frame bracing is employed. In the front and back systems there are in all 16 cross braces between the frames, taking into consideration the high and low pressure cylinder castings. All the cross ties are of cast steel and of such a construction as to provide the maximum of strength with the minimum weight. With but one or two exceptions, the several crossties extend down to the bottom rails of the frames and are secured to the frames by both horizontal and vertical bolts. The location and arrangement of the cross braces are shown in the illustrations of the side elevation and cross section on the accompanying insert.

Two features which have proved very successful in the articulated locomotives built for the Erie Railroad have been incorporated in this design. These are the floating balance device and the side spring buffers at the frame union.

The floating balance device is located between the second and third pair of drivers of the front system immediately back of the boiler bearing which carries the spring centering device and consists of a pair of spring supported columns. These have ball and socket connection at their upper ends with the saddle cast-







DETAILS SHOWING THE HINGE CASTINGS AND FRAME BRACES—D. & H. LOCOMOTIVE.

ing of the boiler bearing to a similar connection at their lower ends with two castings hinged at one end to the bottom of the cast steel crosstie between the lower rails of the frames. The outer ends of these hinged castings rest in "U" bolts and are supported by coil springs seated on the crosstie. These columns serve to support the portion of the weight which would otherwise come on the main boiler bearing, thus relieving that bearing of excessive pressure. In this instance, the total initial compression of the springs is about 30,000 lbs. With this arrangement, that part of the weight of the boiler carried by the front system is divided up between three supports. The surfaces of the boiler bearing, located between the second and third pair of driving wheels are normally not in contact, so that this bearing does not support any weight except under unusual conditions. With this construction the columns are free to sway in any direction, while they support a load equal to the total compression of the four springs.

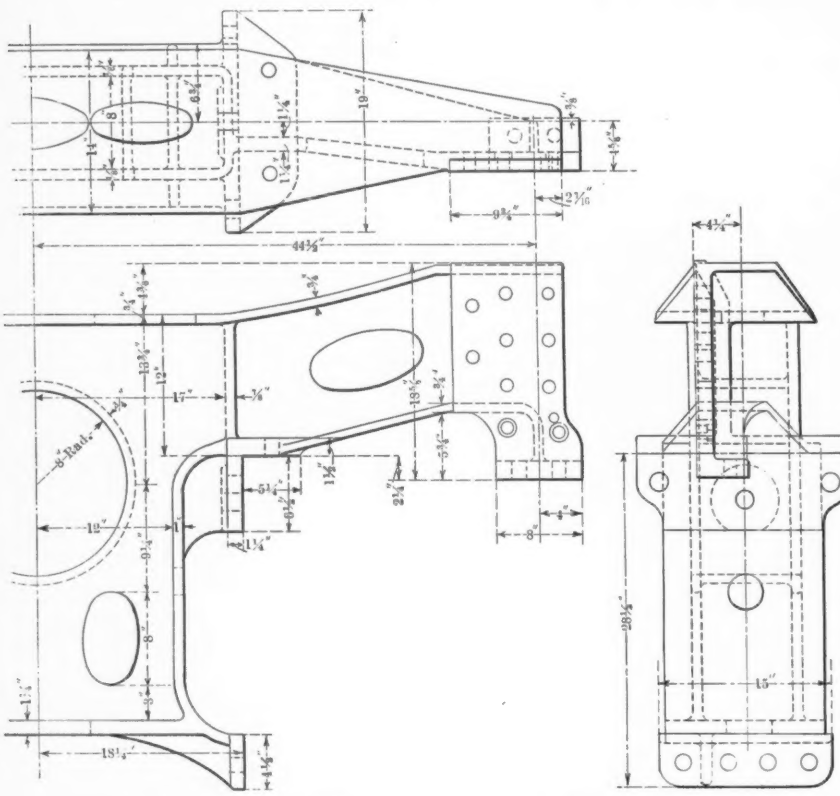
Besides relieving the main boiler bearing of the load which they support, the floating columns throw a certain load on the equalizing bolts in the rear of the frames; since the three supporting points constitute a system of support similar to the balanced beam, with the main boiler bearing as the fulcrum, the loads carried in the supporting columns and the equalizing bolt as the weights applied at either end. Consequently, if the system is in equilibrium, for any load supported by the floating columns, the equalizing beam must receive a load having the same proportion to the other as the respective distances of the floating columns and the equalizing bolts from the main boiler bearing have to each other. As the sum of the loads supported at each of the three points is equal to that part of the weight of the boiler which is carried on the front system, the total amount of the load removed from the main boiler bearing, by the introduction of the floating balance device, is equal to the sum of the load supported by the columns themselves and that thrown on the equalizing bolts.* In this engine, the floating columns are 52 in. from the main boiler bearing, and the equalizing bolts are 65½ in., so that with 30,000 lbs. supported by the columns, about 54,000 lbs. is removed from the main boiler bearing.

In passing through curves, the horizontal component of the force exerted by the springs tends to counteract the increasing resistance of the centering spring, and thus maintain a practically uniform side resistance on curves of different radii.

In engines of the articulated type of ordinary weight, the floating balance device is not necessary, but in designs of such enormous weight as the engine here illustrated, where the bearing pressure on the boiler support would otherwise be excessive, its distinct advantage is apparent.

The side spring buffers are located in the pocket casting of the articulated connection, one on either side, and as far apart as possible. They are so designed that when the engine is on a tangent the buffers just touch the bumper castings bolted to the cast steel crosstie at the ends of the rear frames. Thus, when the engine enters a curve one or the other of the buffer springs is compressed.

When the engine is curving, these buffers serve to direct the pushing force through the center of the wheel base of the front engine instead of through the flange of the outside forward driving wheel as it would be were they not applied. In pushing, the resistance of the head load tends to swing the front system about the center of its wheel base when the engine is passing through a curve, thereby increasing the flange friction of the front driving wheels. The action of the spring buffer is to counteract this side push of the load ahead and thus reduce the resistance.



CAST STEEL GUIDE YOKE AND FRAME BRACE—D. & H. LOCOMOTIVE.

In cases where the wheel base is comparatively long, as in the present instance, and the engine is engaged in pushing service, these buffers have been found to be very effective.

Apart from its enormous size, the boiler is of special interest because of the careful attention with which every detail of the design is worked out, to provide the greatest efficiency. It is of the radial stayed type with conical connection sheet. At the first course the barrel measures 90 in. in diameter outside, while the outside diameter of the largest course is 102 in. The barrel is fitted with 446 tubes, 2¼ in. in diameter and 24 feet long. The arrangement of the tubes is clearly shown in the illustrations of the boiler cross section. The bridges between the tubes are ⅞ in. wide.

The boiler incorporates a 4-foot combustion chamber, which is radially stayed to the shell of the boiler. Ample space is allowed between the combustion chamber and the shell of the boiler on all sides to insure good circulation of the water. The width of the water space is not less than 8½ in. at any point and increases to 11¼ in. at the bottom. Over the crown of the combustion chamber and down to the second row of staybolts above the center line of the boiler flexible staybolts are used. All the plates of the boiler shell are, of course, very thick, the heaviest plate being 1 3/16 in. and the lightest 1 in. The firebox is 114 in. wide and 126⅛ long, and provides a grate area of 100 square feet.

Two Chicago sight feed flange oilers are provided for oiling the flanges of the front and back wheels of each system when the engine is passing through a curve. These are located on the back head of the boiler and oil is fed from them by steam pressure through a pipe line, from which there are leads to the above mentioned wheels.

A single firedoor is provided in the firebox, equipped with a Franklin automatic opener. Iron sliding doors are provided at the back of the cab, which may be closed when the engine is backing.

The tender is fitted with a water bottom tank of large capacity. The tank carries 9,000 gallons of water and the coal space holds 14 tons of coal. In the design of the tender frame

* For a discussion of the weight distribution of Mallet compounds, see AMERICAN ENGINEER, Feb., 1909, page 51.

special care was taken to provide a strong and rigid construction. The longitudinal sills are constructed of 15 in. steel channels weighing 33 pounds to the foot, and top and bottom cover plates are used. Both the front and rear bumpers are of cast steel. The tender trucks are of the four-wheel arch bar type, the design following the Delaware & Hudson Company's standard practice, and have a carrying capacity of 100,000 lbs. each.

The general dimensions, weights and ratios are given in the following table:

GENERAL DATA.	
Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	105,000 lbs.
Weight in working order	445,000 lbs.
Weight on drivers	445,000 lbs.
Weight of engine and tender in working order	611,800 lbs.
Wheel base, driving	14 ft. 9 in.
Wheel base, total	40 ft. 2 in.
Wheel base, engine and tender	75 ft. 7¼ in.
RATIOS.	
Weight on drivers ÷ tractive effort	4.23
Tractive effort × diam. drivers ÷ heating surface	807.00
Total heating surface ÷ grate area	66.29
Firebox heating surface ÷ total heating surface, per cent	5.31
Weight on drivers ÷ total heating surface	67.00
Volume equiv. simple cylinders, cu. ft	26.00
Total heating surface ÷ vol. cylinders	254.00
Grate area ÷ vol. cylinders	3.85
CYLINDERS.	
Kind	Compound
Diameter	26 and 41 in.
Stroke	28 in.
VALVES.	
Kind, H. P	Piston
Kind, L. P	Bal. Slide
Diameter, H. P	14 in.
Greatest travel	6 in.
Outside lap, H. P	1 1/16 in.
Outside lap L. P	1 in.
Inside clearance, H. P	5/16 in.
Inside clearance, L. P	7/16 in.
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	51 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	10 x 12 in.
BOILER.	
Style	Conical
Working pressure	220 lbs.
Outside diameter of first ring	90 in.
Firebox, length and width	126⅛ x 114 in.
Firebox plates, thickness	⅜ and 9/16 in.
Firebox, water space	F. 5, S. 4, B. 4½ in.
Tubes, number and outside diameter	446—2¼ in.
Tubes, length	24 ft.
Heating surface, tubes	6,276 sq. ft.
Heating surface, firebox	353 sq. ft.
Heating surface, total	6,629 sq. ft.
Grate area	100 sq. ft.
Smokestack, diameter	18 in.
Smokestack, height above rail	16 ft.
Center of boiler above rail	10 ft.
TENDER.	
Tank	Water Bottom
Frame	15 in. Chan.
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	9,000 gals.
Coal capacity	14 tons

THE DRAFT GEAR SITUATION.

To the Editor:—

Mr. Adams' pertinent observations* upon the draft gear situation read like a challenge to the draft gear people to make good. The situation, however, is as though one should go to an ordnance engineer and ask him to design a gun that would carry a shot ten miles, and then says: "Now the gun must only be so heavy, so long, have only so much recoil and use so much powder," all of which would make the work required of the gun impossible. The engineer would undoubtedly give you the laugh, but this is just about what the draft gear engineers have been up against, and if the perfect draft gear has not been produced, this is the reason. There probably have been as much, if not more, brains, time, money and effort spent upon the subject of absorbing the shocks of railway cars, as on any other of the elements entering into modern car construction, and as early as the '60's patents began to be issued covering this ground. The essential elements, so well put by Mr. Adams are described almost as well in a patent issued to Pennock in 1867.

During the last two years there have been many changes made in the construction of draft gear, as it has been found that gears that will perform well under slow impact are practically worthless under a quick and heavy blow; also that gears with too easy a starting motion do not absorb sufficient work to prevent a heavy shock, even though the final capacity of the gear was very high, for the acceleration of the blow must be lessened early in the movement to prevent a heavy blow being delivered to the car frame, notwithstanding the gear might be rated at 300,000 pounds capacity. Up to 1907 there had not been a more comprehensive review of the draft gear situation than that given by Mr. A. A. Stucki in his valuable paper before the Railway Club of Pittsburg in December of that year, and the points of the perfect gear as outlined by him, may well be taken, and are being taken, as the standard for which draft gear engineers are working. The requirements of a perfect gear he gives as follows:

"Easy motion at the beginning of the stroke. This is necessary to absorb the small oscillation and lurchings constantly taking place during travel which will rack the car if ignored."

"The recoil should be small, so as to reduce the back lashing after the blow. None the less, the greatest care must be taken that this recoil is sufficient to open the gear under any and all conditions, else you might just as well have a solid block in place of a draft gear."

"Simplicity is one of the most important principles in car construction, and if we had to choose between two gears, one consisting, say, of 5, the other of 20 pieces, everything else being equal, there should be no question as to choice."

"The bearing surfaces should be large, so as to minimize wear."

"The bearing surfaces should be kept flat and well braced so as to get equal pressure all over."

"The design should be of such a nature that machining of the different parts is unnecessary. Such machining is an indication that a delicate adjustment is necessary. The most reliable device is undoubtedly the one that can be made in the foundry and shops, like any other part of the car and which will work in spite of everything being rough, and conditions far from what they really should be."

When the gear closes, all yielding and minor parts should be out of action, and the blow should be transmitted through solid castings to the car just the same as if there were no draft gear present."

Yet with all the experience, data, and basic requirements before them, the draft gear engineers have to confine themselves to a limited space, travel and weight, and must design accordingly.

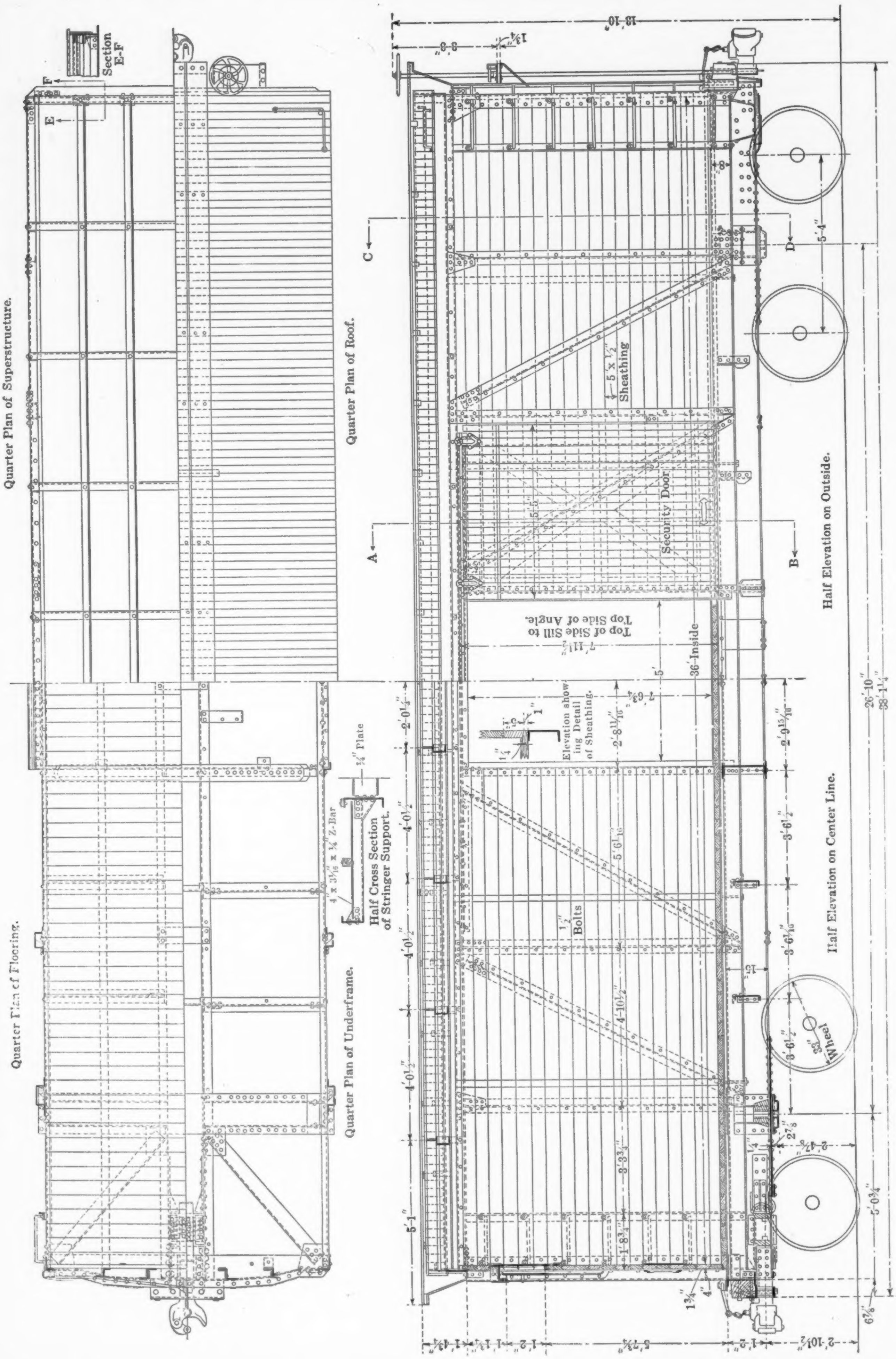
The exhaustive and most interesting tests made during the summer of 1908 on the Southern Pacific Railway, and the later experiments of Col. B. W. Dunn, Chief Inspector of the Bureau for Safe Transportation of Explosives, and other Dangerous Articles, demonstrated beyond all doubt the value of the friction draft gear in absorbing shocks. If the engineers working on the problem have not produced the perfect gear, it is because of the limitations under which they have been compelled to work, but some think they have it almost perfect, and there may be some gears that Mr. Adams has not seen.

W. B. WAGGONER.

Cleveland, Ohio.

EIGHT LOCOMOTIVES TO SIX MACHINISTS.—We get eight engines out per month with but six machinists on the floor. We work piecework and have eight pits, and every pit has a drop. There are two handy men who dismantle the engine with the exception of the ashpans, front ends and pipe work. There is a handy man in the boiler department who takes care of the ashpans. Besides the six machinists on the floor, we have three handy men. Another man is what we call a roustabout. In our motion work the man that handles the links completes the job and sets the valves. The rods are taken down by the handy man and delivered to the fitting shop; the cab mountings are handled in the same way. There is a machinist on the floor that puts the cab work up, but he does not overhaul it. There is mighty little left for the six men on the floor.—*J. A. Boyden at the General Foremen's Convention.*

* See AMERICAN ENGINEER, April, 1910, page 141.



BOX CAR WITH STEEL FRAME. THE FLOORS, SIDES, ENDS AND ROOF ARE WOOD. BUILT BY THE CANADIAN CAR AND FOUNDRY COMPANY FOR THE CANADIAN PACIFIC RAILWAY.

GENERAL VIEW OF CANADIAN PACIFIC STEEL FRAME BOX CAR.

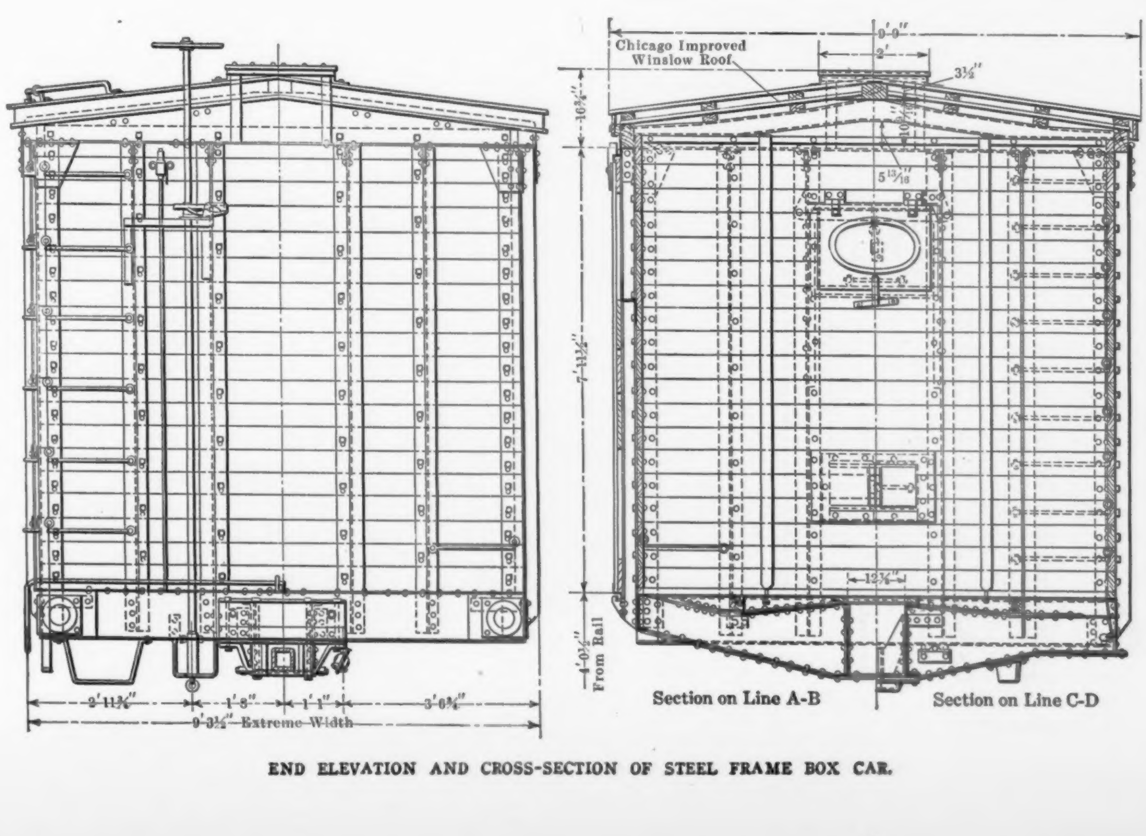
STEEL FRAME BOX CARS.

CANADIAN PACIFIC RAILWAY.

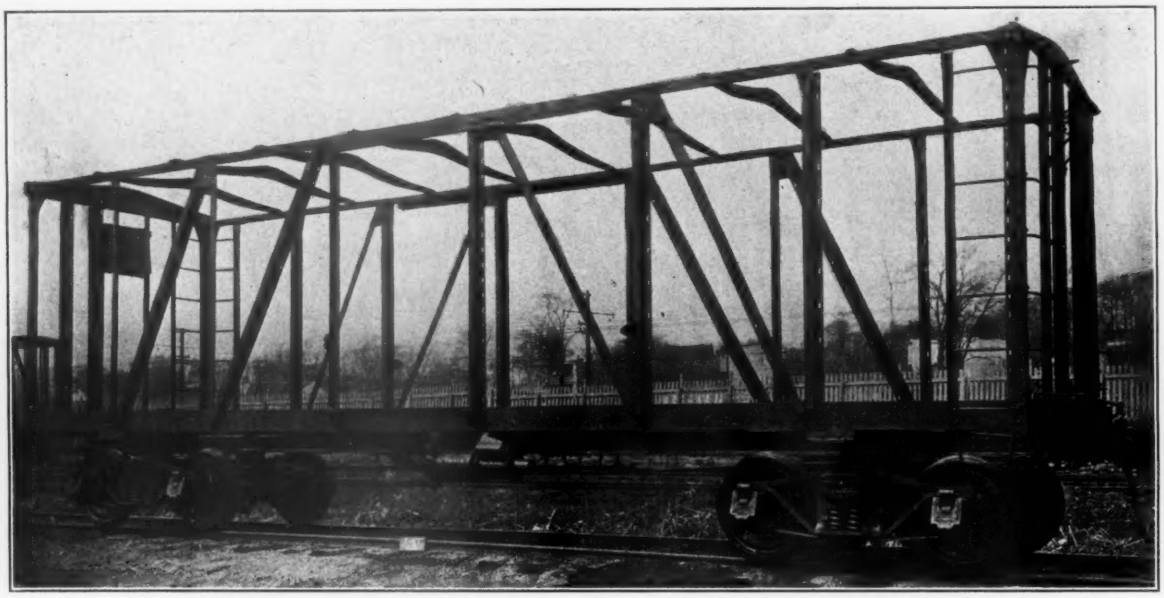
The Canadian Pacific Railway has in service, or on order, two thousand five hundred 80,000 lb. capacity box cars, which were built by the Canadian Car and Foundry Company of Montreal. These cars are 36 ft. inside length and have a steel underframing and steel side and roof framing, the floor, side sheathing and roof covering being of wood. They weigh 36,700 lbs.

Two 15 in. channels set 12⅞ in. apart and continuing from end sill to end sill form the center sills. The side sills are 8 in. channels and are set with their top face 1½ in. above the level of the top flange of the centre sills. The other longitudinal sills in the first order of 500 cars were 4 in. Z bars located mid-way between the side and centre sills and resting on top of the bolsters and cross bearers. In the next 1,000 cars a 3 x 4 in. wooden stringer was substituted and in the 1,000 now being built the Z bar has again been used.

The bolster, which is shown in one of the illustrations, is of the pressed steel diaphragm built up type, having ½ in. cover plates top and bottom. The bolsters extend below and beyond the side sills, which are connected to them by angles and corner brackets, as shown in the illustration. Near the centre of the underframe just below the door posts are two built up cross-bearers composed of a pressed steel diaphragm with a 6 x ½ in. cover and bottom plates, neither of which extend all the way to the side sill connection. Both the bolsters and cross bearers are constructed to permit the intermediate sills, 4 in. in depth,



END ELEVATION AND CROSS-SECTION OF STEEL FRAME BOX CAR.

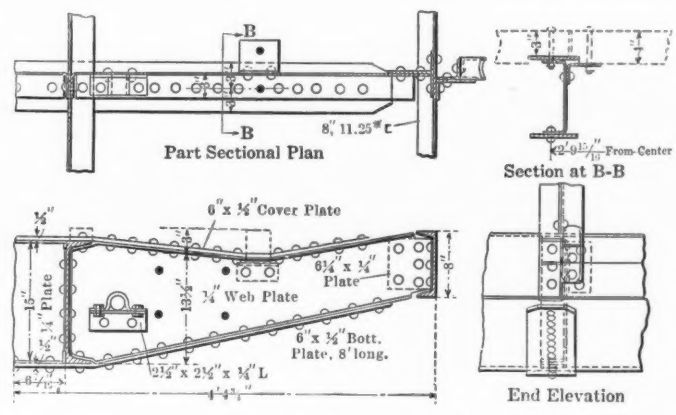


VIEW OF STEEL FRAMING BEFORE SHEATHING OR ROOF WERE APPLIED.

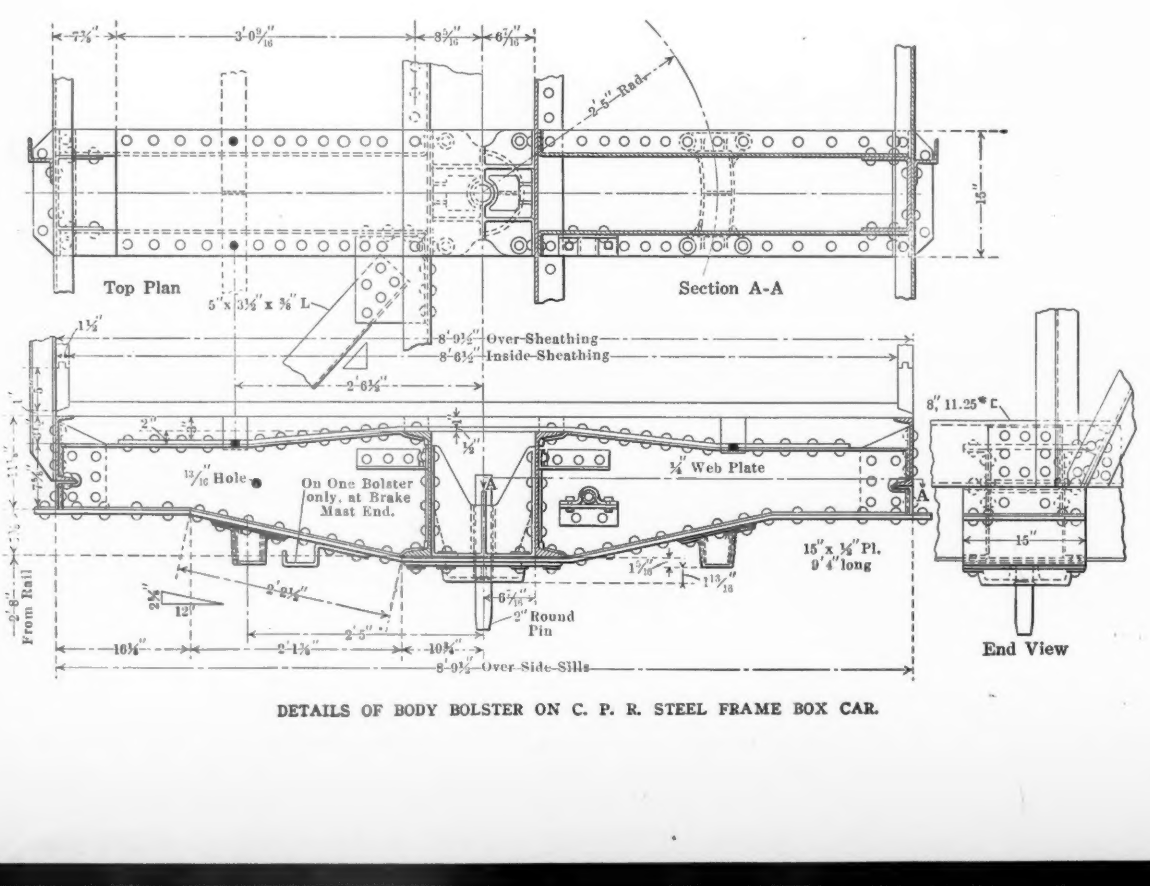
to rest upon them. The end sill is a channel pressed out so as to permit the Z bar end post being secured back of it. Between the bolsters and cross bearers are two cross braces consisting of channels secured between the side and centre sills. There is also a diagonal brace from the corner of the car to the connection between the centre sills and bolster.

The wooden floor is nailed to 1 in. wooden stringers secured on top of the centre sill channels and bolted or nailed to the intermediate longitudinal sills. It is not fastened directly to the side sills, but is held down by the side sheathing, the connection at this point being shown in the small detail given in the illustration of general elevation.

The side framing is composed of 3 in. standard Z bars secured outside of the side sills and to an angle iron plate, the top connection being reinforced with a gusset plate. The corner posts are 5 x 5 in. angles and the two centre end posts are 4 in. Z's, the intermediate end posts being 3 in. Z bars. These are secured to the steel end carlin, which is of the Z section. The carlins are of pressed steel in U section, being arranged to lip over the



DETAILS OF CROSS BEARER.



DETAILS OF BODY BOLSTER ON C. P. R. STEEL FRAME BOX CAR.

side plate and are secured by a rivet through the vertical flange of the plate.

The inside sheathing is tongued and grooved, 1½ in. x 5 in. pine being bolted to the framing. The holes in the steel parts are slotted, and there are tie straps hooked over the top of the sheathing, carried down inside through the side sills and secured with nuts. The inside sheathing extends 3 in. above the bottom of the plates and as it dries out or loosens up the bolts are slacked off and the nuts on the bottom of the tie bars being drawn up will permit the tightening of the sides and ends of the car to the total of 3 in. without leaving an opening at the top. There are two of these tie bars at each end and four on either side.

INTERIOR VIEW SHOWING PRESSED STEEL CARLINS.

Chicago improved Winslow roof has been fitted to the car, the construction being clearly shown in one of the illustrations. They are provided with a pressed steel hinged end door near the top and a small sliding door near the bottom of the ends.

The trucks are of the standard Canadian Pacific Railroad type, equipped with 750 lb. wheels. They have McCord malleable iron journal boxes; Barber roller device; Susemihl frictionless side bearings; Simplex bolsters and brake beams, and American Steel Foundries steel back brake shoe.

The specialties on the car body are Westinghouse air brakes; Simplex couplers and Security side door fixtures.

A GENERAL LOCOMOTIVE INSPECTION

AN ACCOUNT OF THE METHOD OF PROCEDURE, SOME OF THE RESULTS AND THE CONCLUSIONS FOLLOWING A DETAILED INDIVIDUAL INSPECTION OF OVER FIFTEEN HUNDRED LOCOMOTIVES OF ALL TYPES AND SIZES.

By R. H. Rogers.

IN THREE PARTS—PART 2, WHAT IT DEVELOPED.

In the preceding article* the object of the inspection, so far as can be estimated by the writer, was commented upon, and its scope and presentation outlined in some detail. It is now intended to review the conclusions reached on each division after its locomotives had been inspected, and the following is a summary of the conditions existing thereon as they appealed to the inspector, mention being made of conditions both detrimental and the reverse. Those in the detrimental class are the features which most demanded correction in that territory, and naturally embody the chief interest. In the favorable class they are examples of adequate maintenance, which fairness if nothing else dictated, should be mentioned in the final reports from each division.

DIVISION A.

93 Engines. Good, 46; Fair, 30; Poor, 8; Shop, 9. Efficient, 81%.

DETRIMENTAL FEATURES.

(1) Large number of engines with thin tires; 26, or 28%.
(2) Excessive slack between engines and tenders, long drawbars.
(3) Engines with pressed steel tender truck frames broken.
(4) Number of cast iron driving wheel centers broken and banded.

FAVORABLE FEATURES.

(1) General efficient condition of power.
(2) Attention to details: oil cups, cotter pins, metallic packing.
(3) Adherence to standard practises, and quality of back shop output.
(4) Division self-sustaining through its own back shop resources.

DIVISION B.

80 engines. Good, 42; Fair, 21; Poor, 11; Shop, 6. Efficient, 79%.

DETRIMENTAL FEATURES.

(1) Flange wear of driving tires; due largely to careless setting.
(2) Poor condition and care of driving box shoes and wedges.
(3) Excessive lateral motion in engine truck and driving boxes.

FAVORABLE FEATURES.

(1) No bad cast iron tender wheels on the division.
(2) Absence of sharp flanges on engine truck wheels.
(3) Valves kept well squared up on engines of all classes.
(4) Prompt correction of valve and cylinder packing blows.
(5) Speed in back shop operations: setting up and stripping engines.

DIVISION C.

130 engines. Good, 63; Fair, 40; Poor, 17; Shop, 10. Efficient, 79%.

* May, 1910, page 181.

DETRIMENTAL FEATURES.

(1) Poor condition of driving box shoes and wedges, 28 engines.
(2) Flange wear of driving tires. Little attention paid to proper spacing: no verified gauges, and sticks of wood used for this purpose in the wheel gang.
(3) Inadequate wiping of engines; very poor, even passenger engines.

FAVORABLE FEATURES.

(1) Absence of lateral motion in engine truck boxes.
(2) Good condition of cast iron tender wheels.
(3) Back shop output good, but lacks thoroughness in details.
(4) Adherence to shop practise cards.
(5) Ash pans and appurtenances in good condition.
(6) New standards promptly embodied.

DIVISION D.

121 engines. Good, 51; Fair, 50; Poor, 13; Shop, 7. Efficient, 83%.

DETRIMENTAL FEATURES.

(1) Poor condition of switching power, through inadequate care.
(2) Poor condition of driving box shoes and wedges.

FAVORABLE FEATURES.

(1) Clean engines.
(2) Attention to small details: oil cups, sand pipes, cylinder cocks, etc.
(3) Cast iron wheels in good condition.
(4) Absence of flange wear.
(5) Adherence to standard practises.

DIVISION E.

97 engines. Good, 58; Fair, 20; Poor, 10; Shop, 9. Efficient, 81%.

DETRIMENTAL FEATURES.

None of any moment: there was, in fact, nothing to criticise except that the power was poorly wiped, and the care of the oil cups and other small details showed lack of attention.

FAVORABLE FEATURES.

(1) Good condition of driving tire flanges.
(2) Honesty of thorough repairs.
(3) Incorporation of standards.
(4) Close supervision.

DIVISION F.

42 engines. Good, 14; Fair, 10; Poor, 8; Shop, 10. Efficient, 57%.

DETRIMENTAL FEATURES.

(1) Poor condition of rod brasses, due to lack of attention.
(2) Crossheads and guides in same shape through same cause.
(3) Three broken frames in service and inadequately patched.

FAVORABLE FEATURES.

(1) Absence of flange wear in driving tires.
(2) General good condition of cast iron wheels.
(3) Absence of lateral motion in engine truck wheels.
(4) Good cylinder packing.
(5) Oil cup tops on, and well cared for generally.
(6) Good work of light freight power in road service.

DIVISION G.

108 engines. Good, 60; Fair, 26; Poor, 18; Shop, 4. Efficient, 79%.

DETRIMENTAL FEATURES.

(1) Poor valve motion on class z-20 engines.
(2) Engines in service with broken frames.
(3) Inadequate wiping.
(4) Oil cups poorly maintained.

FAVORABLE FEATURES.

(1) Absence of flange wear, due to care in setting tires.
(2) Good quality of back shop work.
(3) Good condition of driving box shoes and wedges.
(4) Percentage of poor tender wheels (cast iron) low; crossheads and guides in fair condition; no driving springs cutting fire-box, and pedestal binders well fit and in good condition.

DIVISION H.

152 engines. Good, 82; Fair, 34; Poor, 19; Shop, 17. Efficient, 76%.

DETRIMENTAL FEATURES.

(1) Improperly fit pedestal binders.
(2) Smoke box fronts in poor condition.
(3) Poor condition of driving box wedges and rods: freight engines.
(4) Excessive lateral motion in driving boxes.
(5) Freight engines wiped only in spots; oil cups not in good condition; injector feed pipes poorly braced, unnecessary slack between engines and tenders because drawbars want shortening.

FAVORABLE FEATURES.

(1) Incorporation of standard practises.
(2) Absence of flange wear of driving tires.
(3) Good condition of passenger power.
(4) Tight cab fittings.

DIVISION I.

95 engines. Good, 41; Fair, 21; Poor, 13; Shop, 10. Efficient, 73%.

DETRIMENTAL FEATURES.

(1) Poor condition of rod brasses and knuckle pins.
(2) Sharp flanges on driving tires, due to improper spacing.
(3) Preponderance of lateral motion in driving boxes.
(4) Sharp flanges on engine truck wheels.
(5) Poorly wiped freight engines.

FAVORABLE FEATURES.

(1) Care taken of compound engines in the renewal of cylinder packing.
(2) Good condition of motion work.

DIVISION J.

99 engines. Good, 47; Fair, 25; Poor, 12; Shop, 15. Efficient, 72%.

DETRIMENTAL FEATURES.

(1) General poor condition of engines not immediately around the principal shop on the division.
(2) Large number of broken frames in service without temporary repairs.
(3) Excessive lateral motion in driving boxes.
(4) Poor condition generally of rod brasses and connection.
(5) Engines with thin tires; below the standard limits.

FAVORABLE FEATURES.

(1) Absence of flange wear of driving tires.
(2) Absence of lateral motion in engine truck boxes.
(3) Smoke box front ends in good condition.
(4) Thoroughness of back shop work.

DIVISION K.

323 engines. Good, 145; Fair, 105; Poor, 38; Shop, 35. Efficient, 78%.

DETRIMENTAL FEATURES.

(1) Neglect of guides and crossheads.
(2) Poor condition of freight power.
(3) Damage to frames by spring hangers.
(4) Clamped and patched broken parts.

FAVORABLE FEATURES.

(1) Absence of lateral motion in engine truck wheels.
(2) Good condition of cast iron wheels.
(3) Close adherence to standard practises.
(4) Outlying points protected with good power.
(5) Close inspection in roundhouses.

DIVISION L.

98 engines. Good, 66; Fair, 23; Poor, 5; Shop, 4. Efficient, 91%.

DETRIMENTAL FEATURES.

(1) Patched, banded and clamped broken parts.
(2) Flange wear of driving tires.
(3) Broken flanges on driving box shoes and wedges.
(4) Improper practises in the fit of driving boxes.

FAVORABLE FEATURES.

(1) Clean engines.
(2) Absence of lateral motion in engine truck and driving boxes.
(3) Careful adjustment of driving box wedges and adequate maintenance.
(4) General good condition of rod brasses and connections.
(5) Lucid and comprehensive office records.
(6) Familiarity on division with actual condition of power.

For those interested in locomotive maintenance there is a limitless field for analysis afforded in the consideration of this presentation of laboriously gathered facts. Confining merely to the detrimental features in the reports quoted, each item in itself is sufficiently suggestive for an article and a discussion, but, as the most recurrent items in the individual engine reports dictated these final conclusions for each division, so must the same in these summaries afford the clue to what must be combated to secure true locomotive efficiency anywhere. The A. B. C. railroad, in fact, need no longer be prominently associated with these articles, as it is logically assumed that the notes gathered on the wear as exhibited by over fifteen hundred fairly modern locomotives, employed in representative freight and passenger service, must to a greater or less degree universally apply, or at least a universal application may be made of the inferences to be drawn therefrom. It is therefore the intent of this article not to discuss the shortcomings or the efficiency of the A. B. C. railroad, but to analyze these detrimental features as broadly representative sources of trouble to motive power management, no matter where located.

After eliminating from the general detrimental features which have been portrayed those which are in a measure controllable, and whose mention simply implies neglect, or lack of adequate organization, the remaining items resolve into the following:

(1) Excessive lateral motion in driving boxes, and to a less extent in engine truck boxes.
(2) Improper condition of driving box shoes and wedges.
(3) Excessive and unwarranted flange wear of driving tires.
(4) Continuance of broken frames in service.
(5) Lost motion in rod brasses and connections.

The above in varying degrees were encountered by the inspector on each division, and may be safely assigned as the principal elements in locomotive deterioration, simply because they were the most recurrent items in the entire inspection.

EXCESSIVE LATERAL MOTION.

This is a most vexatious problem, as a glance behind the driving wheel of almost any locomotive will mutely attest, and singularly enough there is little uniformity among the practises employed to combat it. It was so prominent, indeed, in connection with the fifteen hundred and twenty-six locomotives covered in this inspection, that its mention became necessary in the reports of nine hundred and twenty-one engines, with the further explanation that it was passed unnoticed by the inspector unless the total in any pair of wheels was one-half inch or more. Some of the engines only three months out from general repairs had three-eighths inch end play, although put up with only one-sixteenth inch on each side, or a total of one-eighth inch to start with, and many had a total of one inch, or even an inch and a half, but these latter were, of course, extreme cases.

At the time of this inspection the A. B. C. railroad employed two half circle cast iron liners on the hub of the driving wheel center, and a mixture of special hard babbit for a driving box liner of the following composition:

Tin	86%
Copper	7%
Antimony	7%

Hard as this was, so hard that it would scarcely stick together, it nevertheless proved inadequate, and the repeated mention in the individual engine reports of "excessive end play" inclined the management toward the thought of a more enduring metal for the wearing face of the driving box. Naturally in this connection brass was suggested, but the method of its application to the box resolved into quite a problem. The recommendation finally adopted was that ingot brass should be melted and poured on; this to save the laborious application of a cast liner by patch bolts, and of course the money incidental to the operation.

The only argument in favor of standard cast brass liners to be carried in stock was that the melting of the brass could be restricted to some central shop, and the liners ordered on requisition, but the presentation of the expense to drill some twenty-four holes in the box, tap them, and prepare patch bolts to hold

the liner, was in the aggregate sufficiently convincing for authority to be given each shop to melt its own brass.

For melting purposes the inspector recommended the crucible method. This suggestion was not favorably received at first, as the thought was entertained that in going to crucibles a bill of expense would be run into which would prohibit the system. In the meantime experiments were conducted in one of the shops to melt the brass in an oil furnace with a clay lined ladle, but not sufficient heat could be obtained, and this would no doubt apply to any furnace with less than 16 or 18 oz. pressure in the blast. An easy way out of the difficulty, however, was eventually found by using the spring handing furnace, with which each of the principal shops on the A. B. C. railroad was equipped.

In order to dismiss the fear incidental to the short life of crucibles the writer experimented with various crucible washes, and finally hit on the following combination:

1 part pulverized soft fire brick,
2 parts fire clay.
This is placed in a half-barrel and water added to form a mortar. Apply it to the crucible ⅛ inch thick, and dry in core oven. Additional layers may be applied if it is thought that the crucible requires it.

The writer feels safe in the assertion that this wash will prolong the life of a crucible 100%. Not one when so treated, and of course intelligently handled, will ever let go in the furnace. The coating generally lasts two heats and sometimes more.

Another wash which was suggested while these experiments were under way is as follows, but it has not been tried, and is merely mentioned for what it may be worth:

1 part pulverized soft fire brick,
1 part old crucible,
1 part fire clay.
The treatment of the crucible with this mixture to be the same as that outlined in the wash which was adopted.

Having thus disposed of the problem of melting the brass at all points where back shop work was done, and prolonging the life of the crucibles as well, the next feature was to apply the melted brass to the box in the cheapest and most effective manner. To this end the writer after due reflection prepared and submitted the following shop practise card which was eventually adopted as a standard practice:

All driving boxes to be prepared for brass liners as follows: No less than seven one-inch holes, equally spaced along the center line of the circular groove to be drilled three-quarters of an inch deep in the end play face of the driving box. This drilling must be done with the side or end of the box nearest to the drill elevated on a two-inch strip; this to secure an appreciable angle in the drilled hole toward the center of the box, for the purpose of anchoring the brass liner when poured.

The above is no doubt self-explanatory, but the idea in brief is to slant the drilled holes toward one another; thus when the brass is poured from the crucible it can never come off, as these "tits" are opposing. his practice was eminently successful from the start. The piece work price agreed upon for drilling each box as above indicated was 8 cents, and for pouring the brass, 6 cents. Thus $1.12 covered the labor incidental to applying brass end play liners to eight driving boxes, exclusive, of course, of machining the face of the liner. The immovable nature of the latter when so applied is indicated by the fact that as an experiment it required hard sledging for twenty minutes, with two mauls and a handle chisel, to break one of them off. The writer has never known one to come loose or lose off in service, and there is no need for comment on the superiority of brass over special hard babbit in wearing qualities for this particular part. This practise is equally applicable to engine truck boxes.

So far as the liner on the hub of the driving wheel center is concerned, there is little to criticise in the A. B. C. standard of two half circle pieces of cast iron, secured by patch bolts of iron or brass (not copper). The requisite, of course, is to secure something which will protect the center from wear, and not fall off. In view of the latter probability these liners should always be in two pieces, thus affording an opportunity for the roundhouse to take care of on the drop pit any case where one or both of them may be lost, which it could not do if they were solid, or in one piece, as has been frequently observed. The general inspection of the A. B. C. railroad indicated only twenty-seven instances where these half-circle cast iron hub plates were missing; hence they may be defined as adequate for the purpose intended.

Before dismissing this subject it is believed that the rapid wear of the special hard babbit when employed as driving box end play liner is much more intensified through its peculiar affinity for grit. While not offering this as a positive assertion, experience leads to the belief that grit clings readily to a babbit surface, and thus grinds out the part, while it seems to fall from a brass liner. The substitution of brass for babbit appeals as a move in the right direction and in the consideration of all the sound arguments which can be advanced for its use it is amazing that it is not of universal application. The writer believes that should another inspection be made of the A. B. C. railroad the end play problem would appear as easily controllable, instead of looming up as the predominating feature in deterioration, as it did in this instance.

DRIVING BOX SHOES AND WEDGES.

At the time this inspection was made the individual reports indicate that no less than seven hundred and sixty-three engines embodied driving box shoes and wedges in a condition far below the requirements of any standard of maintenance for these parts. Criticism was principally leveled at the fact that they were allowed to run on at least two divisions when set up as far as they would go, that is, tight against the top of the frame. In such instances comment is, of course, superfluous, as they simply imply lack of organization, or the failure to properly view in their true importance the internal disturbing factors introduced in the locomotive through their continuance. But from a strictly mechanical standpoint the following may be noticed in the examination of the engines of any railroad where they are engaged in heavy service: (1) Shoes and wedges heavily "shouldered" above the driving boxes, (2) a very large percentage with flanges broken off.

In explanation of the shouldered feature mentioned this is intended to refer to that portion of the shoe or wedge more prominent in the former as it extends the entire length of the pedestal, which remains above the shoe and wedge faces of the driving box, and hence escapes being affected by the "rub" of the latter as the box shifts in the jaws while the engine is running. Sometimes this inequality in wear amounts to as much as one-eighth inch, and it is decidedly objectionable, as if an attempt is made to properly adjust the wedge under such conditions it will likely be stuck with the first inequality of track which will elevate the box to come in contact with the unworn or shouldered portion of the shoe. It is of tremendously far-reaching effect, because the engineers with a lively recollection of unpleasant experiences, hesitate to set up their wedges, knowing the result as above intimated, and in consequence the majority of heavy freight engines in this country, if "thumped" under steam, will likely exhibit a heavy pound in the driving boxes between the shoe and wedge faces. The wretched condition of rod brasses and knuckle joint connections on many of these engines will mutely attest that the rods are doing all the work, due to the unstability of the driving boxes arising from loose wedges which will not run set up owing to the inequality in the wearing face of the shoe.

It is a matter, however, easily and cheaply corrected, and scarcely another machine operation can be mentioned which in the end will yield such satisfactory results. The following remedy is suggested as a shop practise card:

In machining shoes and wedges a 3/32-inch cut must be planed or milled on the wearing face, 4 inches in length (not arbitrary) measured from the top. In certain cases it may be advisable to treat the bottom of the wearing face in the same manner.

It will be recalled that this practise is invariably followed in planing guide bars, in what may be called "end clearance" between them, and which permits the crosshead to be pulled to the extreme or the "striking" points. When embodied in shoes and wedges as above outlined it permits a perfect adjustment of wedges, and is readily affected whenever these parts are down, but of course properly belongs to the time when the engine is receiving general repairs. This train of thought was suggested

following an inspection where the general wedge conditions were unduly flagrant, and in reply to criticism it was advanced that they "could not be set up without sticking"; without question absolutely correct, as has been explained.

In regard to the second ever present feature in connection with shoes and wedges, viz., broken flanges, the question arises whether or not this may be construed as anything objectionable or detrimental, but waiving this possible argument, the fact remains that something is broken, and there must necessarily be evinced a weakness repellant to advanced mechanical ideas and procedure. It may not be credited, but the writer has seen a 4-4-0 light passenger engine with each and every flange broken off the total of eight shoes and wedges which this wheel arrangement implies.

The reason for this, and all other breakages of similar kind, is that not sufficient clearance exists between the flanges of the shoes and wedges and the pedestal legs, and between these flanges and the flanges of the driving boxes; in other words, a too much "straight up and down" proposition. With everything a "fit" the slightest cant of the locomotive frame in either direction, and there are lots of them even at reasonable speed imposes a prohibitive strain on all of these parts, to the extent that in extreme cases something must inevitably let go. This something is, of course, the comparatively weak cast iron flange of the shoe or wedge.

A good practice to follow, and which will result in reducing to a minimum the breakage of flanges, is to slightly taper the inner face of the driving box flanges from the center both ways to the ends. This total taper need not be over 1/16 inch, but this will be ample to take care of whatever rocking motion the driving box may assume when the engine is running. This is necessarily another back shop operation, and it is earnestly recommended, as there is nothing the roundhouse can do in combating the problem of broken flanges except repeated renewals of the shoes and wedges, which soon runs up a formidable bill of expense in addition to detaining the engine from road service.

Before this item is dismissed another feature must need be commented upon, and that is the neglect which generally associates with the proper care of wedges. Innumerable instances are recalled where the liners added from time to time to take up wear were "tacked" on, and in consequence had worked out and over the top of the driving box so that it would be practically impossible to oil the latter. It is no less than amazing after all the hard work has been done of taking down the binder, and often a driving spring as well, to remove the wedge, that the liner should be hastily stuck on with two insignificant ⅛ inch copper rivets, yet it is in evidence every day, although with the realization that the arrangement is scarcely permanent enough to take the engine out of the roundhouse. No liner should be allowed less than ⅛ inch thick, which is the minimum for an adequate countersink in the rivet holes; and no less than eight ¼-inch rivets, equally distributed, should be employed to secure it. The job is to take down and re-apply the heavy parts, and certainly nothing can be advanced against consuming sufficient time to fasten the liner so it will stay until another liner must be applied, which should mean four months at least, no matter what the character of the service may be.

The importance of properly maintaining this part is not underestimated by scarcely any railroad, and on the large majority of them the roundhouse organization provides for what is called a "shoe and wedge man," who with one or two helpers is charged with "keeping them up," not only so far as lining when required is concerned, but the proper adjustment as well. In such organization this man is supposed to keep an eye on all of the wedges under his jurisdiction, and in addition to doing the work in that line reported by the engineers and the engine inspector, to take the initiative when he notes anything in need of repair.

Theoretically, this may be all right, but in its practical working becomes largely a farce. With the possible exception of the steam pipes, the shoe and wedge job is the meanest and most disenchanting proposition on a locomotive. In recent years the binders have become tremendously heavy. They are generally fit with draw to the pedestal, are hard to wedge down, and very hard to pull up to where they must go to be re-applied properly. Many engines have underhung springs, and it is then necessary to remove the spring before starting on the binder. It is besides a strictly "pit" job, and every move is performed under the disagreeable environment of standing in cold water with hot water dropping from above. Naturally a shoe and wedge man, no matter how conscientious he may be, is only human after all, and in the absence of definite orders from some one regarding his work, is very liable to let the job go until it has reached distressing proportions, especially where the organization provides that he largely finds his own work.

After long consideration of this matter the writer recommends that specialists on the shoe and wedge job be discontinued. It is confidently believed that far better results will materialize by the roundhouse foreman handing these jobs as they occur to any one of the running repair hands who may be disengaged at the time. This will result in placing the foreman closer in touch with these parts, and he will watch and hurry the job, being desirous to secure the use of that running repair man on something else, whereas he could not use a regular shoe and wedge man on anything other than his work, a situation which creates indifference toward the latter.

This recalls that a surprising ignorance has often been noted on the part of roundhouse foremen in regard to the actual condition of the wedges in engines under their direct supervision. On one occasion the writer took a foreman for a walk along a string of engines on the ash pit, and pointed to the fact that five of these, all in heavy freight service, had one or more wedges set up as high as they would go, and the box playing backward and forward to the detriment of rod brasses and connections. He said, and honestly the writer believes, that he had not the slightest idea conditions were so bad, and that the engineers running these locomotives had not reported their wedges in need of lining. They were chain gang engines, and a review of the work book showed that reports of this nature were quite infrequent. The writer then requested the road foreman of engines to take the matter up with the engineers to learn why they had not brought the matter to the attention of the shop supervision, and the investigation in time developed that they had become indifferent since against their wishes the engines had generally been pooled. They added that when this procedure was established a "let-up" ensued all around, in the shop as well as in their former attention.

However this may be, there is no intention to offer an argument relative to the chain gang system, now generally prevalent, one way or the other, but the fact remains that the time-honored care of wedges which the engineers have apparently let go, the shop must now assume. One reason why things are so bad in this line is because the adjustment of wedges, at least, was generally attended to by the engineers, and the shop has not come to a full realization that they no longer experience the old interest.

The writer believes that for the present, at least, the only real solution for this problem is to station an inspector on the ash pit, for whose benefit the engine will be "thumped" under steam before the hostler brings it into the house. In this form of inspection the lost motion in any part is most apparent, and the report covering the condition of the wedges, or the pound of the driving boxes in the jaws, could reach the roundhouse foreman coincident with the arrival of the locomotive on its pit. This will effectually dismiss the excuse that they had not been advised of conditions which to all intent and purpose were practically pounding the engine to pieces.

FLANGE WEAR OF DRIVING TIRES.

This is ordinarily associated in fancy with divisions of railroads having more than the average degrees of curvature, but the observations of the writer serve to dismiss this view as entirely erroneous. For instance, on the A. B. C. railroad it was found that the straightest division indicated the most cut flanges, while

on another, exceedingly crooked, the flange wear remained merely at the average for what might be expected in the instance of heavy power. The cause of flange wear is improper spacing of the driving wheel tires, helped along by excessive lateral motion in engine truck boxes.

So many errors in the correct setting of tires have been noted on so many railroads, that, in the consideration of flange wear, improper spacing of tires must be assigned as the primary cause. Improper spacing in this sense is intended to mean carelessness in securing the exact measurement from one time to another, on the same pair of wheels, as laid down in the standard practises.

There are certain recognized standards for the spacing of the tires, for instance on 2-8-0 type, 53⅜ inch for Nos. 2 and 3 pair, and 53¼ inch for Nos. 1 and 4 pair, and the mere matter of living up to these standards, and even disregarding all contributing causes of flange wear, will in most cases reduce this trouble fifty per cent. This will appear an extravagant statement, as it would imply that a disregard of standards exists in all cases where tire troubles are in evidence. It should not, however, be so construed, but rather that there is a laxity in the shops in this important regard which escapes the management, who, with the knowledge that prints and instructions exist, thoroughly covering the matter in detail, are often lulled into a false security, under the impression that the mere presence of these in the tire gang conveys the assurance that they will be lived up to.

From records covering the close inspection of hundreds of engines during the past few years, wherever flange cutting has been in evidence the writer notes some remarkable variations from standard practises. One instance in particular should be mentioned, that of a 2-8-0 engine, 17 feet rigid wheel base, with all flanged tires, which actually had the front tires spaced 53¾ inch, and, quoting from the report: "⅝ inch wider than spacing for best results, and ⅜ inch wider than any recognized spacing." This is, of course, a somewhat extreme case, but it actually occurred on a well handled railroad, simply because the confidence in the tire foreman was misplaced.

Another engine of the same class had tires spaced as follows: No. 1, 53 7/16 inch; No. 2, 53 7/16 inch; No. 3, 53½ inch; No. 4, 53¼ inch. Still another example: No. 1, 53⅜ inch; No. 2, 53½ inch; No. 3, 53½ inch, and No. 4, 53 5/16 inch. In this arrangement the first pair of wheels in each engine had tires at least ¼ inch further apart than any recognized spacing; Nos. 2 and 3, ⅛ inch further apart than any practise, and No. 4, ⅛ inch in excess of the best practise. Another engine had front driving tires 5/16 inch too far apart, and another ⅜ inch. Each of these engines showed pronounced flange cutting. A pleasing contrast was afforded, however, in still another engine of the same type. This had Nos. 1 and 4 set at 53⅛ inch, and Nos. 2 and 3 at 53⅛ inch, and exhibited no flange wear whatever, or even rubbing, although the tires had been on five months and the engine had made the same, if not more, mileage than the others mentioned.

The above examples, while occurring on one road, are merely illustrative of what has been encountered on several others, and every one of these roads had shop practise cards and blue prints covering all necessary information to secure correct tire-setting. On one of these, which ran through a mountain country, with all the popular causes present against the longevity of flanges, such vigorous action was taken on the portrayal of these conditions that seventy-five per cent. of this abnormal flange wear was eliminated within the ensuing six months. The measures which brought about such a gratifying result were: (1) Replacing the measuring sticks of wood, and other makeshifts which had been in use in the wheel gang, by solid gauges with hardened points, one set for each class of engine, and by impressing on those concerned that they must wake up to the importance of the matter; (2) the issue of clear prints for shop use, giving the standard practise for setting tires on all engines, and (3) temporarily at least providing an inspector to gauge every set of tires after mounting in the wheel shop, and certify on a regular form to the correctness of the setting.

It has been said that the insistence on attention to the details in the wheel shop will eliminate fifty per cent. of flange troubles, and the writer firmly believes this to be true. The correction of contributing causes must devolve upon the care and vigilance exercised in the roundhouse after the locomotive has been put in service.

It is of utmost importance along these lines to keep within reasonable limits the inevitable accumulation of lateral motion in the engine truck wheels. An excess of this, which should be taken to mean anything greater than ½ inch total, is without question the principal contributing cause to driving tire flange wear. Excessive lateral motion in the engine truck results in the leading driving tires being most affected by high degree curves; in other words, the engine truck does not receive its share of the impact of the curve. When this lateral motion is combined with excessive wide spacing of the front driving tires there could be no other logical result than excessive flange wear or flange cutting.

Ideal conditions, however, will not have been reached until all wheel centers are standardized, and all tires bored with a lip. The tire then applied to the center so far as the lip will allow is properly spaced in relation to its mate on the opposite wheel. This is said, of course, with a full realization that should the lip tire plan be adopted, a long time must elapse before the good results which will certainly follow can fully materialize. This is because wheel centers on old engines are frequently at variance with standards; many are too far apart, while some are too close, and in consequence, facing the outside of the rim to bring the standard lip tire to its proper position would have to vary with each individual case. The soundness of the lip tire idea, however, will be readily appreciated by those familiar with the hurry and handicap imposed when tires are changed in roundhouses. The chances for error in the setting, which are frequently in evidence under such conditions, would entirely disappear, as the tire could only be applied to the center as far as its lip would allow.

BROKEN FRAMES IN SERVICE.

There is little of value to comment on in connection with this particular feature, as it is generally conceded that fractured frames should not be continued in service, but they are so continued, although it is not believed that the management is cognizant of such procedure. Some broken frames, of course, are placed immediately on the hospital list through the location of the break, for example, immediately back of the cylinder, in the tongue piece or front rail. There are many other fractures, however, which do not incapacitate the locomotive for the time being, and in ninety per cent. of instances they are winked at by the local supervision, and the engine allowed to run until such time permits, if it ever comes around, when the engine can be best spared for repairs.

The great trouble in this connection is that the roundhouse foreman, ever busy in meeting the exact requirements of his daily schedule, can scarcely be expected to exhibit the finesse of feeling to look far into the future of a single locomotive, especially when that locomotive is apparently doing its work, even if the frame is in two pieces. It is a matter for the master mechanic to know, and to know personally, through a system of reports which admit of no evasion, the condition of each and every frame under his jurisdiction. By taking this matter into his own hands, and having his force understand that he handles it, the roundhouse foreman in his turn will exploit what it now looks very much as though he was covering up.

Briefly broken frames should not be run for this reason: the break attests to the presence of an abnormal stress, and after the fracture occurs these strains must be transmitted to and borne by some other part of the frame which never was designed to sustain this double duty. Thus metal fatigue is set up in parts far removed from the original defect, and may serve to explain the many failures which occur in other parts of the frame after the primary break has been welded up and the engine returned to service.

There is another point in connection with broken frames, and

worthy of deep reflection, viz., their welding when these fractures occur. The writer has little faith in the stability of a thermit weld, and less in one made by oil, on a "V" piece set into the break. Without recourse to argument he believes that oil welds are only brazed at best, and that although they may apparently hold are no less than a menace to security. One of these latter is recalled, made with great care in one of the principal shops of the A. B. C. railroad, famed for just this class of work, which let go in the one hundred and forty miles to the next division. Its cross section showed only thirty per cent. of the metal united in the weld.

Although conceded somewhat radical the recommendation is offered that when the break occurs the engine be retired from service and the frame removed to be honestly welded up under the hammer. This convincingly disposes of the matter, whereas conjecture must predominate when other makeshifts are employed.

It is unfortunate that a thorough study has not been made of the efficacy of the various welds. It might easily be done, too, by stamping in a clean place on the frame adjacent to the weld a certain symbol to indicate the nature of the weld. For instance, the letter "T" would indicate thermit; "O," oil weld, and "F," an honest forge weld. Then when any of these failed a good record would be inaugurated for the future, and from which many more binding inferences might be drawn than in the present hap-hazard procedure.

LOST MOTION IN ROD BRASSES AND CONNECTIONS.

The design of these parts is generally adequate, and a thorough review, in this instance at all events, seems to show that when in an abnormally bad condition the latter results from the driving box wedges being even worse. With enough bang between the shoes and wedge faces to almost permit the driving boxes to turn over in the jaws at each revolution of the wheels it is not likely that perfection will evince in the much less massive rod bearings. When the wedges are all the way up, and no longer hold the boxes, the double duty is imposed on the rod brasses and knuckle pins to not only turn the wheels, but keep the wheels properly aligned as well: something, of course, impossible for them to do for very long.

Of course, the writer encountered instances in plenty where the wedges were in good condition, and the rod brasses were poor, but this simply spelled neglect, and does not alter the above general conclusion.

It looks absurd, when the matter is properly understood, and there is no mystery about it, to see a roundhouse foreman give a machinist a work slip to take down the intricate and cumbersome middle connection side rod brass for the purpose of reducing it, while right behind that same wheel the driving box wedge is jammed against the top of the frame, and no longer serving the purpose for which intended. Common sense would certainly dictate to line that wedge to-day, and reduce the brass to-morrow, then the latter will be in the nature of an enduring job, but vice versa it will have to be reduced again next week, unless it is the intention to allow it to knock the pin off, or break itself to bits.

The writer is advised that in a certain roundhouse 200 rod brasses were applied in a single month, and this was pointed to with pride, as an illustration of the care which they were taking of their rods, but if the condition of the shoes and wedges on those engines when inspected was representative of the period referred to this heavy application need not be considered unusual. If this labor had been spent in part in lining down wedges, and keeping them adjusted where they belonged, probably one hundred of these new brasses, not to mention innumerable knuckle pins, might have been saved. Only the intelligent handling of the shoe and wedge proposition will ever result in adequate maintenance of rod brasses and their connections. It is practically killing two birds with one stone.

The above consideration of five points embodies what the writer believes to be the secret of prolonging the life of an engine between shoppings, and just the way they are viewed and lived up to is the gauge of success in this line for any division. It was not the intention in the foregoing to dilate on self-evident truths, but merely to present what the inspector offered to the A. B. C. railroad in solution, or at least as a move in the right direction. The minor elements of deterioration, the organization employed to combat them, and the effect of personality on locomotive maintenance will be reviewed in the next and final article in this series.

TEST OF LOCOMOTIVE DRIVING WHEELS.

ACCURATE MEASURING OF THE DEFORMATION OF DRIVING WHEELS DUE TO THE CENTRIFUGAL ACTION OF THE COUNTERBALANCE AND THE THRUST AGAINST THE FLANGE WHEN CURVING. ALSO THE AREA OF CONTACT BETWEEN THE WHEEL AND RAIL.

E. L. HANCOCK.

The investigation of the deformation of two locomotive driving wheels due to the various forces acting upon them is outlined below. The object of the test on wheel No. 1 was to determine the deformation due to the centrifugal force of the counterbalance, and to determine, if possible, whether or not this deformation was sufficient to account in part for the presence of flat spots on drive wheels just in front of the counterbalance. It was thought that this centrifugal force might be great enough to cause the wheel to roll in a slightly elliptical form. To determine whether or not such deformation was possible, it was decided that tests should be made in a testing machine. In addition to these, tests were made to determine the deformation while under load and the area of contact of the wheel with a 90-pound rail. The wheel was furnished by the American Locomotive Company. The center was of cast steel, the whole wheel weighing 3,500 pounds and with dimensions shown in Fig. 1.

The tests were made in a Riehle testing machine of 300,000 pounds capacity. For the tension tests the wheel was arranged as shown in Fig. 2, so disposed as to admit of the application of tension along a diameter through the center of the crank pin and counterbalance. In order to prevent unusual distortion due to the hole in the center of the wheel, a cast iron plug was driven in from the convex side. Rods were attached along the vertical and horizontal diameters to projecting pieces of steel soldered to the tread and projecting out over the flange. A

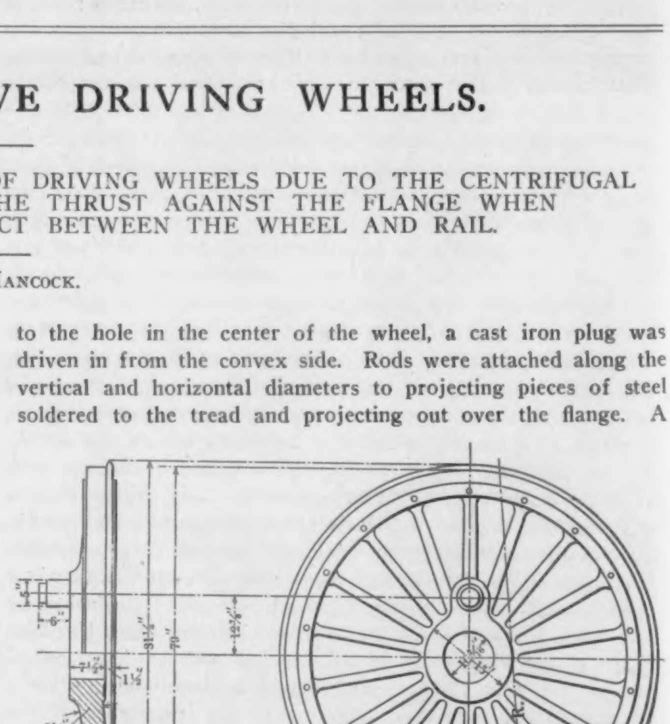


FIG. 1.

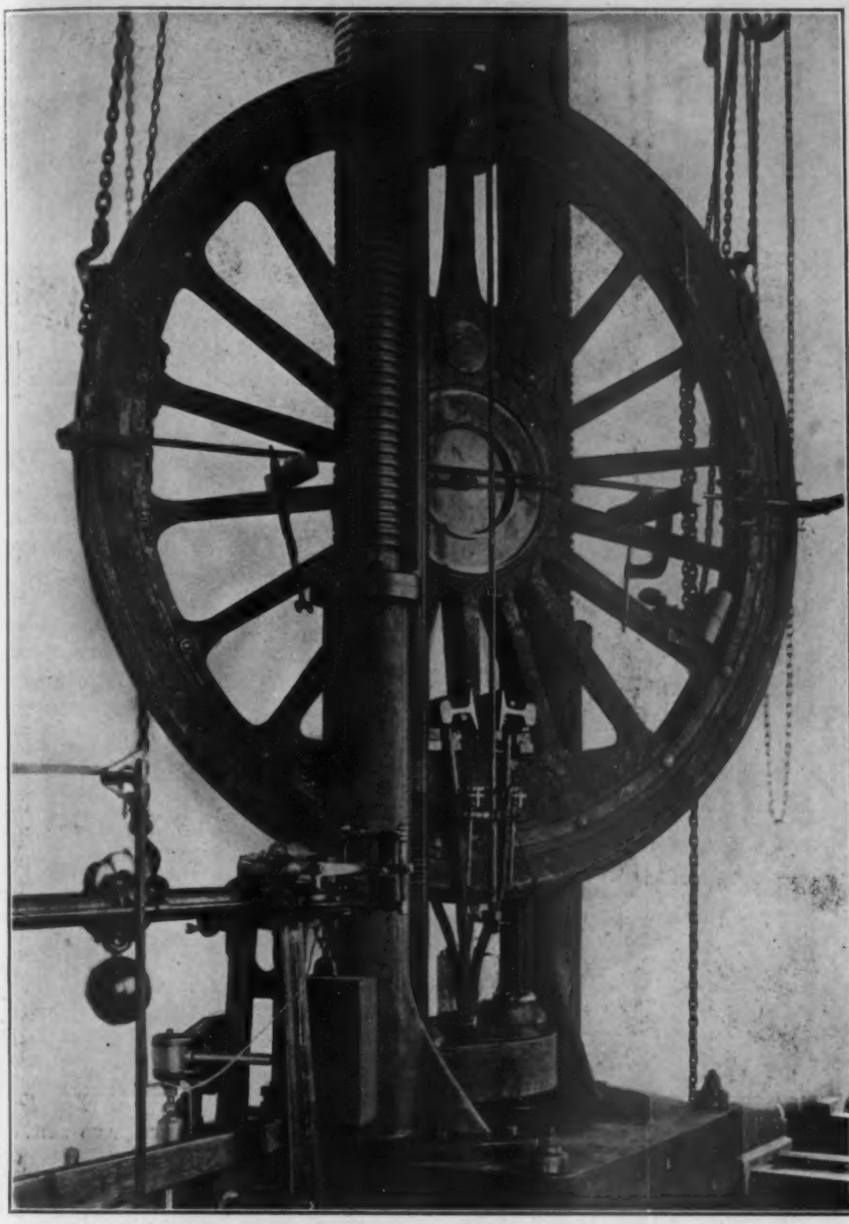


FIG. 2.—DRIVING WHEEL IN RIEHLE TESTING MACHINE.

short piece of tubing fitted over one end of the rod in such a manner as to admit of extension along the diameter. Extensometers were placed on each of these rods, one end being on the piece of tubing and the other on the rod. In this way when the diameter of the wheel changed, the rod moved in the tube and this movement was measured by means of the extensometers. The extensometers were of the Riehle type, measuring to 1/10000 of an inch. Great care was used in getting the pieces soldered to the tread and in adjusting all parts connected with the measuring apparatus.

To guard against accident, two chains, shown in Fig. 2, were kept in place. These chains were loose during the tests.

Loads were applied in increments of 3,000 pounds, and the resulting deformation measured along the two diameters. The results are shown by curves (1) and (3), Fig. 3. These curves represent the average of three tests. In each case it was found upon releasing the load that there was no set in the wheel.

A second series of tests were made by pulling from the hub and counterbalance. The arrangement was the same as that shown in Fig. 2, except that the large chain at the top, instead of pulling from the rim, was extended around the hub. The results of these tests are shown by curves (2) and (4), Fig. 3. In this case, also, no set was observed when the load was released.

The force of 60,000 pounds applied, for an unbalanced mass in the counterbalance of 800 pounds weight, corresponds to a speed of 250 miles per hour.

For a speed of 100 miles per hour the estimated pull would be about 10,000 pounds. If such a force acts along the diameter through the crank pin, it is obvious that the wheel should be stiff enough along a diameter at right angles to prevent any appreciable deformation of the wheel. From curve (1), Fig. 3, it is seen that the deformation of the diameter due to a pull of 10,000 pounds is about .002 inches, an amount that certainly might be neglected. From tests made by Professor Goss it is evident that the wheel lifts off of the rail at times. If we assume that this lifting force may be due to the centrifugal force, say 25,000 pounds, the change of diameter is only .0045 inches. Even the change in diameter caused by the pull of 60,000 pounds is so slight as to have no practical significance. It does not seem probable that the total deformation was not measured by the method employed since the test was repeated many times with almost identical results. Further evidence of the accuracy of the method of measurement is seen in the return to the same zero each time after the load had been removed.

The next series of tests was designed to show the deformation due to the load by measuring the area of contact between the wheel and rail. For this purpose the apparatus was changed somewhat, the cast iron plug being driven through the hub until it projected equally on each side, so that the projecting ends might rest upon columns supported on the base of the testing machine. (See Fig. 4.) A section of a new 90-pound rail was clamped in an inverted position to the under side of the moving head of the machine in such a way that when lowered, it gave contact with the tread of the wheel. The load was then applied by lowering the moving head. In other words, the rail was pressed down upon the wheel instead of the wheel being pressed upon the rail.

Areas of contact were measured at different points on the tread, keeping the rail always in the same position relative to the flange of the wheel. These areas were taken by inserting a piece of carbon paper and a piece of white tissue paper between

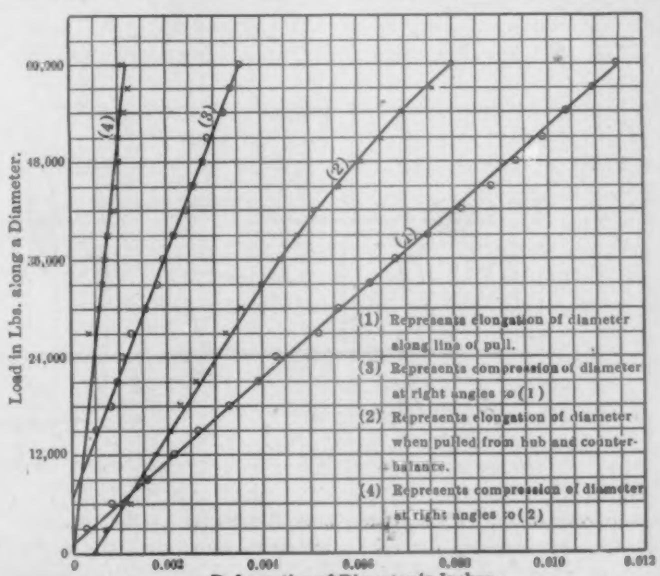


FIG. 3.

the wheel and rail. After the load was applied the print of the area of contact was left upon the paper where it was measured by means of a planimeter. Areas were measured at points along the tread indicated by Fig. 5, and the results are shown by the curves. Loads were applied in increments of 5,000 pounds up to 25,000 pounds. The results of these tests seem to show that there is less deformation of the wheel when the rail is in the vicinity of the crank pin than for any other position and a greater deformation when the contact is 90 degrees from that position. In other words, that the wheel is stiffer along a diameter through the crank pin than along any other diameter.

To extend the tests made on wheel No. 1 and to check their validity, tests were made on another wheel which we shall designate as wheel No. 2. This second wheel was much heavier in all its parts than the first, weighing with hub and crank pin 5,700 pounds. It is shown in section in Fig. 6. The tension test was omitted in this case, since the deformations obtained from the tension tests of wheel No. 1 were so small. The wheel was mounted as shown in Fig. 4, and areas of contact with a 75-pound rail were taken at different points on the tread. Possible changes of length of the diameter at right angles to that of the contact point were measured by extensometers arranged as in the case of the tension tests on wheel No. 1, Fig. 2. This wheel was also furnished by the American Locomotive Company; both wheel and rail were new. Areas were taken by means of carbon and tissue paper as before, and the chains shown in Fig. 4 were loose during the tests. Areas of contact were taken for various loads up to 80,000 pounds. These areas are shown in the following table:

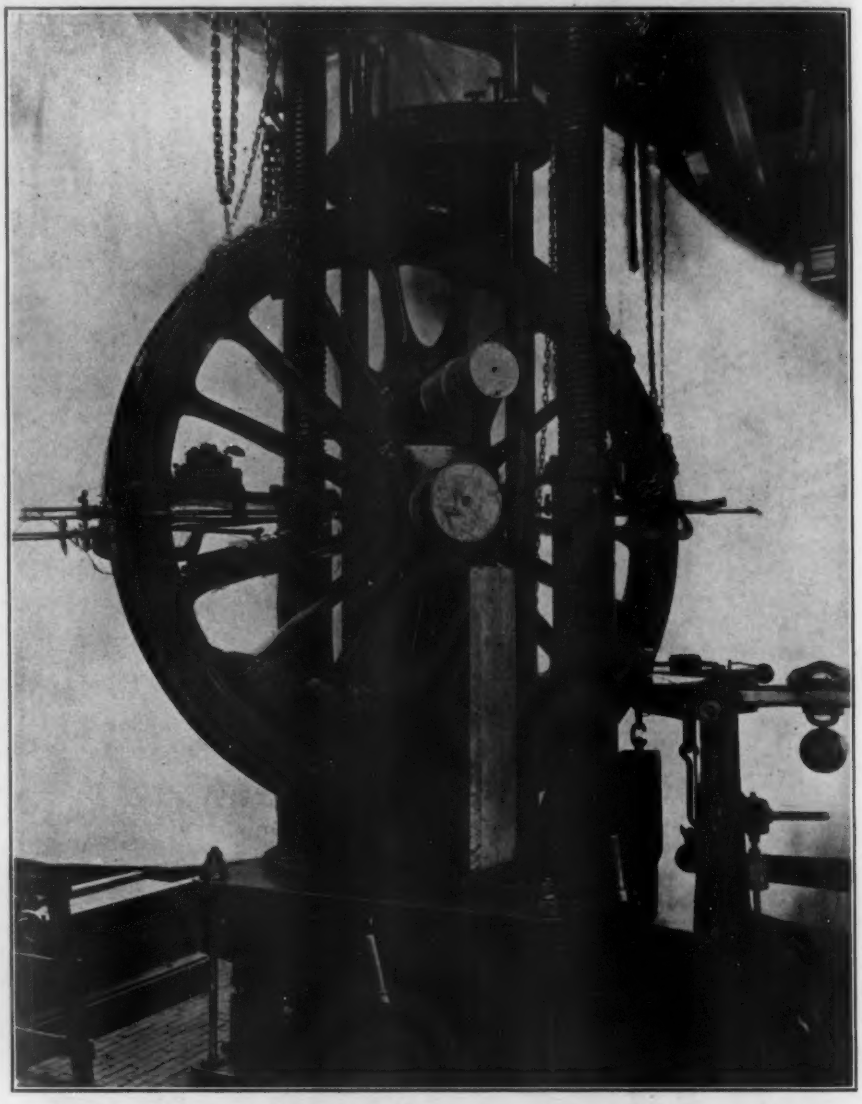


FIG. 4.—TESTING FOR AREA OF CONTACT BETWEEN WHEEL AND RAIL.

Load in pounds.	Area midway crank pin and counter-balance in sq. in.	Area counter-balance, sq. in.	Area crank pin, sq. in.	Average area, sq. in.
10,000	.36	.33	.35	.346
20,000	.48	.52	.51	.503
30,000	.57	.61	.63	.603
40,000	.68	.73	.74	.716
50,000	.75	.75	.81	.77
60,000	.80	.85	.92	.856
70,000	.91	.95	.99	.95
80,000	1.00	1.01	1.02	1.01

Here the areas taken midway between the crank pin and counterbalance are smaller than the others, indicating less deformation of the tread. Those taken over the center of the counterbalance were smaller for this wheel than those over the crank pin. As above noted, an effort was made to detect any change of diameter of the wheel caused by the application of the load. The extensometers, which measured to 1/10000 of an inch, gave no indication of any change. Both Riehle and Johnson extensometers were used. Since there was no change in diameter the increased area obtained at the crank pin must be accounted for by a local bending of the tire and rim. This view is further confirmed by the fact that in this wheel the areas over the crank pin were greater than those over the counterbalance, while in the case of wheel No. 1 the reverse is true. By referring to Fig. 2 and Fig 4 it is seen that the area over the crank pin in 4 came between two spokes while in 2 it was directly over a spoke. The area midway between the crank pin and counterbalance in 4

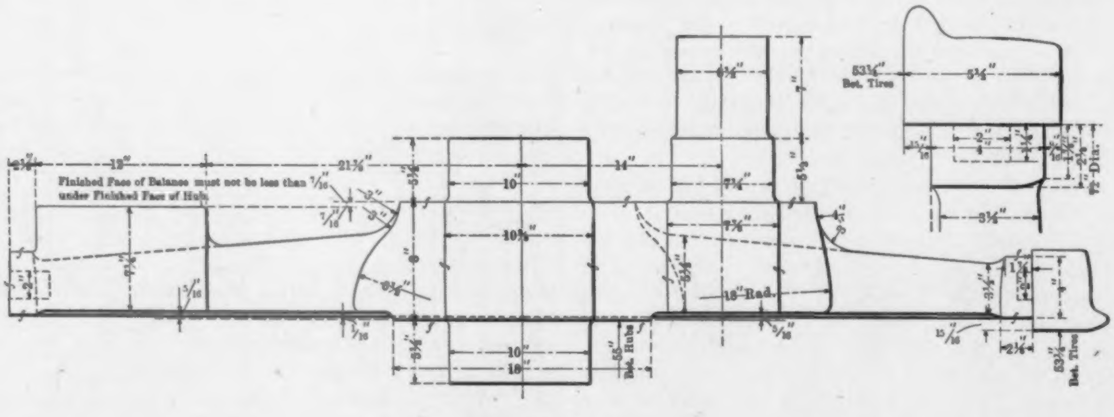


FIG. 6.

was over a spoke, while in 2 it was between two spokes. No further tests were made to determine whether or not this view regarding local bending as the sole cause of the difference of areas of contact for different points on the tread, was correct. It seems, however, a fair way of explaining the facts observed.

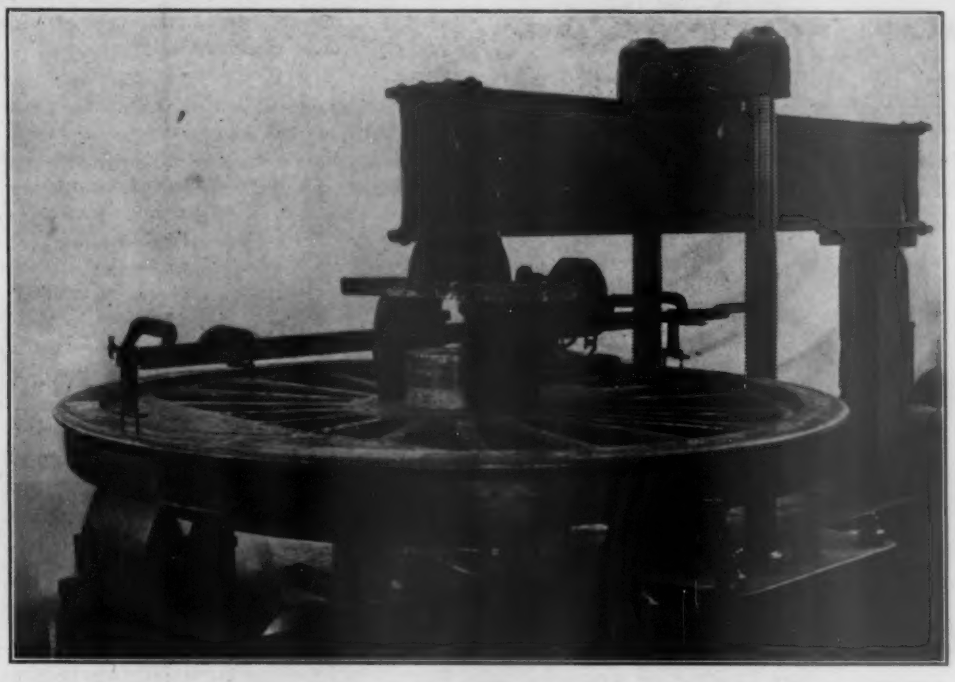


FIG. 7.—WHEEL MOUNTED FOR TESTING EFFECT OF FLANGE PRESSURE.

This wheel, No. 2, was also tested for deflection due to transverse loads, viz.: such loads as would be caused by flange pressure against the rail. For this test the wheel was mounted on

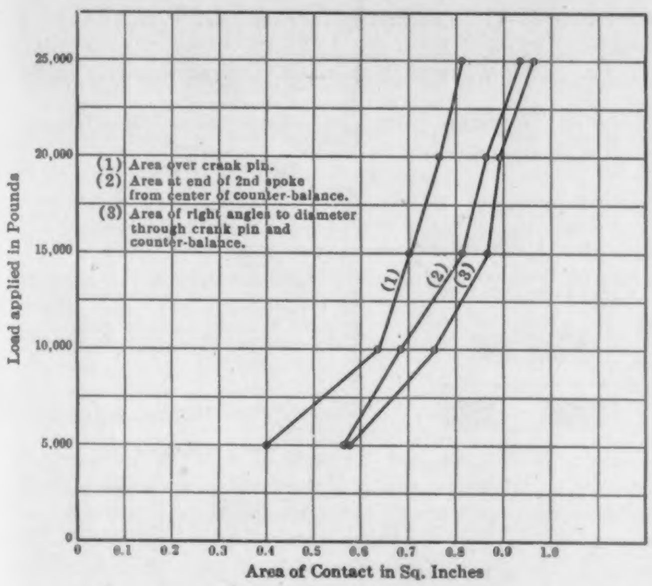


FIG. 5.

one arm of a 200,000 pound Riehle testing machine, as shown in Fig. 7. The weight of the wheel was counterbalanced on the other arm of the machine and loads applied at the center as shown in the figure. Deflections were measured in thousandths of an inch for loads of 1,000 pounds up to 40,000 pounds. Several tests were made with the wheel in the position shown, and the average of these tests is shown by curve (1), Fig. 8. Then the wheel was turned and supported with the knife edges at the extremities of a diameter through the edge of the counterbalance. Curve (2), Fig. 8, shows the average of these tests. Finally the wheel was supported with the supports at the extremities of a diameter at right angles to the position shown in Fig. 7. The results of these last tests are shown in curve (3), Fig. 8. It is seen from these curves that the deflection for the various loads is about the same for the positions (1) and (3) and somewhat less for position (2). This means that the wheel is stiffer when the flange pressure is at the edge of the counterbalance than for the other positions.

It is to be noted that the wheel was not supported at the flange as in service, but by supports 77 inches apart. The results of the tests show that a formula for deflection in which the deflection varies as the cube of the diameter, holds approximately in this case. Considering the wheel supported by the flange, this gives the deflection for (1), for the 40,000 pounds pressure, as .098 inches instead of .091 inches, as read from the curve.

It is appreciated that supporting the wheel as was done and applying the load at the center does not exactly reproduce the conditions of service, but it is believed that it approximates them as near as may be done in a static testing machine. It is believed that this flange pressure of 40,000 pounds is greater than any so far obtained in track tests for lateral pressure. In the *Railroad Gazette,* Sept. 20, 1907, Mr. Geo. L. Fowler reports, for a consolidation locomotive weighing 174,300 pounds and running at 30.6 m.p.h. on a 4 degree 25 min. curve a maximum drive wheel pressure of 13,000 pounds. It is to be noticed, however, in this case that the superelevation of the outer rail was 3.875 inches,

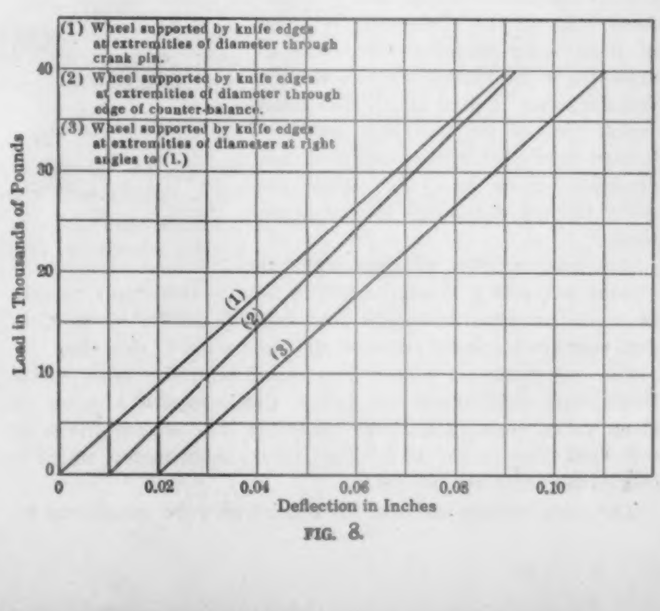


FIG. 8.

corresponding to a speed of 36.6 m.p.h. It is certain that at speeds exceeding this limit the flange pressure would be considerably increased. The rather large pressure of 40,000 pounds allows for extraordinary conditions.

AUTOMATIC MACHINES FOR LOCOMOTIVE PARTS.

In almost all modern railroad shops at the present time there is an increasing tendency to the use of turret lathes for the manufacture of small parts such as screws, studs, etc. The degree of efficiency attained by these tools of course is very good, but in most cases for certain small parts to be made constantly in large quantities the output can be increased to a remarkable extent by the use of automatic machines.

LOCOMOTIVE PARTS MADE ON AN AUTOMATIC MACHINE.

The use of automatic screw machines in railroad work is somewhat of a departure from the usual practice, but in a modern shop where the work is centralized there is no reason why these machines should not be used more extensively. While a good turret lathe may possibly do the same work somewhat faster,—the cost of production with the use of automatic machines can be reduced about *four* or *five* times because one man with a helper can easily operate about ten of these machines.

Four automatic screw machines have been in service for a number of years at one of the large modern shops and are giving very satisfactory results. Two of these were manufactured by the Cleveland Auto. Machinery Co., and the max. size of the work is 2¼ x 6 in. and 2¼ x 4 in. respectively. The other two are the No. 54 and No. 56 Acme multiple spindle machines, with four heads, manufactured by the National Acme Mfg. Co., of Cincinnati, Ohio, one of them being equipped with tools to make 1⅞ in. adjustable staybolt sleeves, and the other is used chiefly for small studs. One of the Cleveland machines is used chiefly for turning out pins such as driver brake pins, etc., while the other is used for small miscellaneous work.

One man operates all these tools at present, but with a helper he will be able to very easily operate twice that number when the requirements of the whole shop shall warrant the installation of additional tools of this kind.

The four tools are placed in a group with five brass turret lathes; and eight other iron lathes, which require a motor of about 30 h.p. capacity, although the group is at present driven by a Bullock Electric Co. 18 h.p., 900 r.p.m., shunt motor, which is overloaded about 100 per cent.

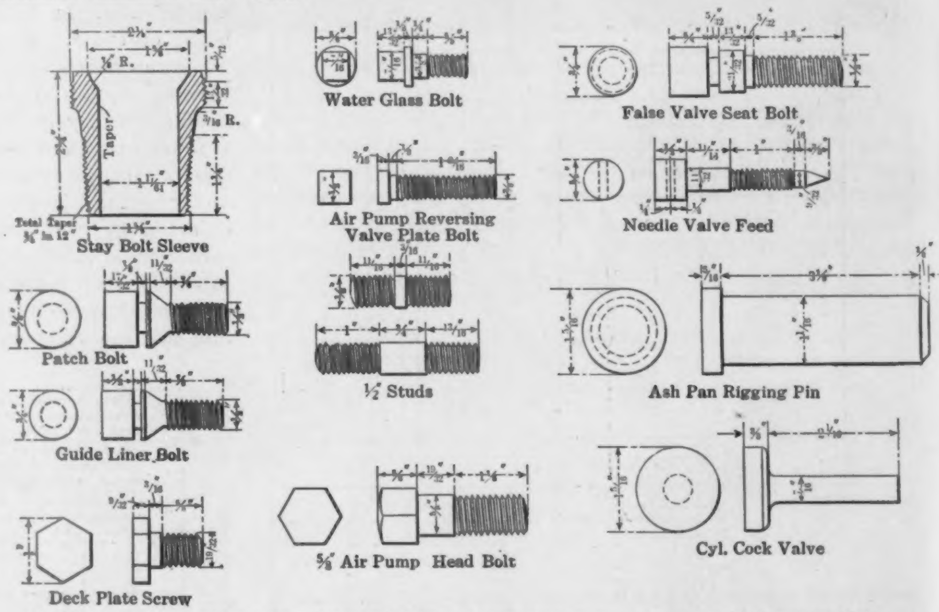
The great variety and also the quality of work turned out by these automatic machines may be somewhat of a surprise to many railroad shop men, but when we consider that this work is done at one-quarter the cost of the same work on a turret lathe it seems truly remarkable. The cost could be still further reduced if all these parts were made in a centralized shop for several divisions so that more machines could be installed. Some of the work which these machines are turning out is shown in the illustration.

Red Seal engine oil is used as a cutting lubricant and gives very good results, the oil being of course used over and over again.

The large pin shown is used on ash pan rigging, requires about *eight* min. to finish as shown, or, in other words the output is 75 pins per 10 hr. day on a Cleveland machine. The same machine turns out 180 studs ⅝ x 1 in., or about 210 studs ½ x 1 in., in 10 hrs., while the Acme No. 54 multiple spindle machine turns out about 400 ½ x 1 in. studs in a 10 hr. day. The capacity of the Acme No. 56 is about 75 flexible staybolt sleeves in 10 hrs., or 8 min. per sleeve. The sleeves are all completed on this machine except balling out the top to receive the spherical bolt head.

The supervision required is practically nothing and while they do not turn out work much faster than some good turret lathes, it is evident that it can be done more economically and also with more speed when two or more additional machines can be set up for the same work in case of emergency to obtain an increased output.

We have less trouble with boiler failures since we began using a hot water washout system. Our boilermakers were on a strike for six weeks and we did not have a delay on account of a boiler failure.—*C. L. Dickert at the General Foremen's Convention.*



DETAILS GIVING DIMENSIONS OF LOCOMOTIVE PARTS MADE ON AN AUTOMATIC MACHINE.

The Pennsylvania established a new record during the month of March in overhauling engines at the Altoona shops. In all, 205 locomotives were received at the shops and repaired. Of this number, 35 were given what is known as heavy running repairs, while the remaining 170 were given repairs to various broken parts.

The East River tunnel of the Pennsylvania R. R. at New York will be in operation about August 15.

STATISTICS OF MOTIVE POWER D

FOR YEAR ENDING JUNE

	NEW ENGLAND		EASTERN								
Name of road	N. Y., N. H. & H.	B. & M.	P. R. R.	Penn. Co.	N. Y. C.	B. & O.	Erie	L. S. & M. S.	P. & R.	L. V.	D., L. & W.
Miles of track	2,045	2,288	5,307	1,342	2,829	3,446	2,114	1,520	1,492	1,393	957
Number of locomotives owned	1,187	1,073	4,094	1,006	1,894	1,729	1,417	921	1,061	873	751
Number of freight cars owned	33,751	27,039	115,817	37,624	66,556	81,753	52,214	40,887	42,810	41,533	28,292
MILEAGE, ETC.											
Miles per passenger locomotive	29,000	29,000	37,000	50,000	37,000	48,000	28,000	43,000	32,000	33,000	34,000
Miles per freight locomotive	16,000	24,000	15,000	17,000	19,000	21,000	18,000	21,000	16,000	19,000	21,000
Miles per total locomotive	24,000	27,000	24,000	27,000	28,000	29,000	20,000	28,000	23,000	23,000	26,000
Average weight on drivers per locomotive in tons	47	46	70	66	67	65	67	71	57	63	64
Average tractive effort per locomotive, pounds	22,000	20,000	32,000	30,000	30,000	31,000	28,000	31,000	27,000	27,000	26,000
COST OF MAINTAINING EQUIPMENT.											
Cost of maintaining equipment per locomotive mile—cents	20	16	32.5	24	23	21	31	24	32	29.5	17.5
Cost of maintaining equipment per train mile—cents	26	22.5	49	34	32.5	29	42	36	49	44.5	35.5
Cost of maintaining equipment per 1,000 revenue ton miles—dollars	3.15	2.20	1.50	1.30	1.80	1.20	1.65	1.20	1.95	1.35	1.35
Cost of maintaining equipment per work unit†—dollars	9.10	8.20	10.12	8.00	7.80	6.80	11.20	7.80	12.00	10.80	9.20
Cost of maintaining equipment per road unit*—dollars	215	175	235	180	175	160	230	170	280	230	185
Percentage of maintenance of equipment to operating expenses	16	16.5	28	25	24.5	23	30	23.5	32	28	25
Percentage of maintenance of equipment to gross earnings	11	12	19.4	15.9	17.1	15.4	20	15	19.2	17.4	13.6
COST OF MAINTAINING LOCOMOTIVES.											
Cost of maintaining locomotives per locomotive mile—cents	7.2	5.4	10.2	8.2	6.8	7.2	13	6.2	9.8	10	6.2
Cost of maintaining locomotives per locomotive—dollars	1,750	1,500	2,500	2,250	1,900	2,100	2,650	1,700	2,250	2,250	1,700
Cost of maintaining locomotives per 1,000 revenue ton miles—dollars	1.15	.75	.48	.44	.53	.42	.70	.30	.58	.45	.36
Cost of maintaining locomotives per pound of tractive effort—cents	8	7.5	7.8	7.4	6.2	6.8	9.6	5.4	8.5	8.4	6.4
Cost of maintaining locomotives per work unit†—dollars	3.30	2.75	3.50	2.80	2.25	2.35	4.80	1.95	3.65	3.65	2.45
Cost of maintaining locomotives per road unit*—dollars	77	60.	74.	64.	50.	55.	100.	42.	86.	78.	49.
Percentage of maintenance of locomotives to operating expenses	6	5.8	8.8	8.4	7	8	12.8	6	9.6	9.6	6.5
Percentage of maintenance of locomotives to maintenance of equipment	36.5	34	31.5	34	29	35	42.5	25	30	34	26
Percentage of maintenance of locomotives to gross earnings	4	4.1	6.1	5.4	5	5.4	4.5	3.7	5.8	6	3.6
MAINTENANCE OF FREIGHT CARS.											
Maintenance of freight cars per freight car owned—dollars	32.	50.	60.	48.	92.	54.	50.	72.	80.	50.	51.
Percentage of cost of maintaining freight cars to operating expenses	3.2	4.4	8.4	9.2	9.8	8.8	8.8	11	14	10	7.5
Percentage of cost of maintaining freight cars to freight earnings	4.2	5.5	8.2	8	12	7.8	8	11	11	7.5	5.6
COST OF MAINTAINING SHOP MACHINERY AND TOOLS.											
Shop machinery and tools per 1,000 locomotive miles—dollars	9	1.60	6.20	5.10	5.	6.	7.25	6.60	6.	7.	6.60
Shop machinery and tools per locomotive—dollars	220	45.	150.	140.	140.	175.	150.	185.	140.	160.	170.
Shop machinery and tools per 1,000 revenue ton miles—cents	14.2	2.2	3.0	2.8	4.0	3.4	4.0	3.2	3.6	3.2	3.8
Shop machinery and tools per work unit†—cents	41.5	8.	19.5	17.5	17.	19.5	27.	22.	22.5	26.	25.
Shop machinery and tools per road unit*—dollars	9.70	1.80	4.50	3.90	3.70	4.70	5.60	4.70	5.40	5.50	5.10
Percentage of shop machinery and tools to maintenance of locomotives	12.4	2.8	6.	6.2	7.2	8.2	5.6	11.	6.1	7.	10.5
Percentage of shop machinery and tools to maintenance of equipment	4.5	1.	1.9	2.1	2.1	2.9	2.4	2.7	1.9	2.4	2.7
Percentage of shop machinery and tools to gross earnings	.49	.12	.37	.34	.37	.45	.47	.40	.36	.42	.38
Percentage of shop machinery and tools to operating expenses	.74	.17	.54	.52	.52	.68	.72	.64	.59	.68	.68
COST OF LOCOMOTIVE FUEL.											
Cost of fuel for locomotives per locomotive mile—cents	17.4	14.6	10.2	9.0	10.7	8.2	11.5	11.6	11.2	14.0	10.5
Cost of fuel for locomotives per locomotive—dollars	4,200	3,900	2,450	2,450	3,000	2,400	2,400	3,200	2,650	3,200	2,800
Percentage of cost of locomotive fuel to operating expenses	14.4	15	8.6	9.1	11.2	9.1	11.2	11.3	11.1	13.6	11.0
Pounds of freight locomotive fuel per 1,000 revenue ton miles	640	660	420	390	530	640	570	370	550	530	460
Revenue tons of freight per freight train	270	240	640	470	410	430	470	610	450	530	510
1,000 revenue ton miles per freight locomotive	4,000	5,000	7,600	7,600	6,600	[illegible],000	7,500	11,400	6,500	8,800	7,800
Revenue tons of freight per loaded freight car	14	14	27	24	16.5	22	21	19	23	23	22
Percentage of revenue tons of freight per loaded car to average capacity	45	51	62	60	45	60	56	50	70	64	70
Density of traffic—1,000 revenue ton miles per mile of road	900	900	4,400	3,700	2,300	2,300	2,700	3,400	3,800	3,050	3,750

† Work unit = tractive effort in pounds × locomotive miles ÷ 1,000,000.
* Road unit = weight on drivers in pounds × locomotive miles ÷ 100,000,000.

The data for this table is taken from the reports submitted by the various railroads to the Interstate Commerce Commission for the year ending June 30, 1909. In presenting this, it is realized that inaccurate conclusions may possibly be drawn from these figures, particularly in connection with comparing one road with another.

It is well understood by those who are familiar with railroad statistics that there are many factors which must be taken into consideration in comparing one system with another with the idea of determining the relative efficiency of the managements. It will be readily appreciated, for instance, that a road operating in a mountainous territory cannot be compared in items of locomotive maintenance, fuel consumption, or shop tools and machinery with a system operating through level country. This fact is well illustrated by taking two sections of the Atchison, Topeka & Santa Fe Railroa Chicago to Wellington, Kans., a distance of over 700 mi pared with the district from Belen, N. M., to the coas practices and scheme of operation of these two section way and the locomotives employed are particularly well s they operate, but the cost of locomotive repairs and fu the first district is 26.4 cents, while on the second distri character of the country they traverse.

Another feature which should be remembered in th for one year's operation only and that an unsatisfacto

R DEPARTMENT OPERATION

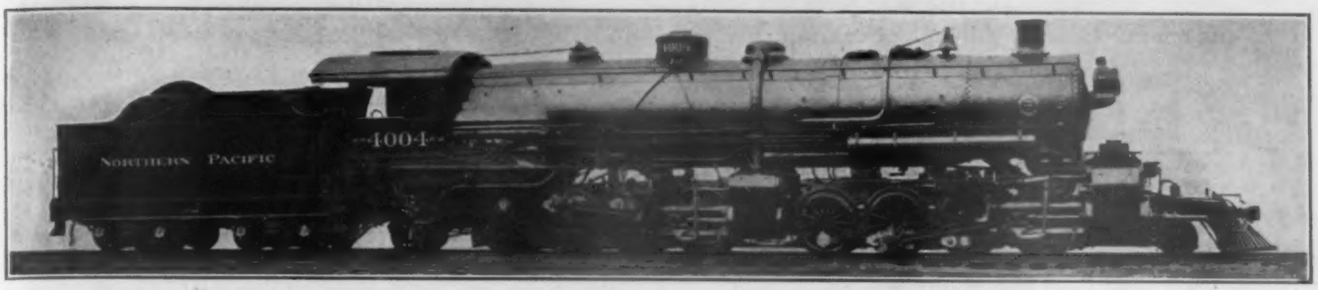
G JUNE 30, 1909

	CENTRAL AND SOUTHERN				MIDDLE WESTERN						SOUTH WESTERN		NORTH WESTERN			
D., L. & W.	P. C. C.-St. L.	Sou. Ry.	L. & N.	Ill. Cen.	C. B. & Q.	C. & N. W.	C. R. I. & P.	M. P.	U. P.	S. L. & S. F.	S. P.	A. T. & S. F.	N. P.	C. M. & St. P.	G. N.	Can. Pac.
957	1,472	7.055	4,349	4.378	9,022	7,632	7,526	6,489	3,299	4,740	5,718	5,573	5.672	7,286	6,923	10,106
751	632	1,523	887	1.238	1,676	1,452	1,361	1,053	656	892	1.305	1,612	1,347	1,423	1,065	1,478
28.292	23.633	52,371	41,010	67,255	54,780	59,760	40,583	44,414	15.450	30,182	25,933	45,045	42,208	55,488	42,920	50,434
34,000	47,000	37,000	53,000	49,000	39,000	52,000	36,000	51,000	53,000	49,000	49,000	27,000	40,000	58,000	39,000	33,000
21,000	24,000	17,000	32,000	20,000	19,000	22,000	20,000	20,000	18,000	17,000	15,000	19,000	15,000	26,500	13,000	22,000
26,000	32,000	25,000	35,000	29,000	27,000	33,000	27,000	30,000	29,000	26,000	26,000	25,000	24,000	37,000	23,000	31,000
64	64	59	59	56	58	47	58	59	68	56	60	64	67	47	67	59
26,000	28,000	29,000	27,000	24,000	23,000	22,000	26.000	30,000	30,000	25,000	27.000	30,000	30,000	20,000	30,000	26,000
17.5	25	21	25.5	31	30	16	19	22	25.5	15	30	29	25	17	25.5	24
35.5	33	26	30	38	39	21	23	27.5	32	22.5	42	36	32.5	18	34	30
1.35	1.75	2.25	1.85	1.85	2.05	1.60	1.85	1.70	1.50	1.80	2.40	2.20	1.50	1.45	1 25	1.80
9.20	9.10	7.20	9.25	12.75	12 80	7.40	7.30	7.30	8.30	7.20	11.20	9.80	8.20	8.40	6.90	9.30
185	200	180	210	270	255	175	165	185	185	160	250	225	185	185	155	205
25	25.5	23	26	28	24.5	18	18	21	21.5	19	22	24.5	21	18	18	22
13.6	17.6	15.8	17.2	21	17	12	12.4	15.2	10.2	12.2	13	15	11.5	12	11.5	15.4
6.2	8	7	8.2	9.2	7.4	5.8	8.4	9.8	11.2	9.2	11.5	9.8	7.2	5.4	5.4	10
1,700	2,550	1,800	2,800	2,700	2,000	1,900	2,300	2,900	3,250	2,400	3,100	2,500	1,750	2,000	1,800	3,100
.36	.55	.75	.59	.56	.50	.58	.82	.75	.65	.91	.94	.75	.44	.45	.40	.75
6.4	9.4	6.2	10.6	11	8.5	8.8	9.2	9.8	10.8	9.6	11.5	8.2	6	9.8	6	12
2.45	2.90	2.45	3.00	3.80	3.20	2.70	3.30	3.20	3.70	3.70	4.35	3.30	2.40	2.70	2.15	3.90
49.	63.	60.	68.	82.	68.	62.	74.	81.	82.	82.	99.	77.	55.	57.	59.	86
6.5	8	7.8	8.6	9	6	6.5	8.2	9	9.4	9.6	8.5	8.2	6.2	6	6	9.2
26	32	33	32	30	25	36	45	44	44.5	50.8	39	34	30	32	32	42
3.6	5.5	5.2	5.5	6.4	4.2	4.3	5.6	6.6	4.6	6.2	5.1	5.1	3.4	3.8	3.6	6.5
51.	96.	50.	62.	92.	64.	40.	68.	58.	104.	50.	110.	110.	42.	70.	34.	58
7.5	9.8	7.4	8.5	15	6	5.5	6.2	7.5	6.8	6	6.6	8.8	4.5	8	4.5	5.5
5.6	10	7.8	7.8	16	6.2	5.4	6.8	7.5	4.6	5.8	6.2	8	3 8	7.3	3.7	6
6.60	6.80	3.50	4.20	7.	6.50	3.00	4.40	4.70	8.80	3.20	6.40	6.10	3.50	5.50	3.20	7.50
170.	220.	85.	145.	200.	175.	95.	120,	140.	250.	85.	170.	155.	85.	205.	70.	230
3.8	4.8	3.8	3.0	4.2	4.4	2.8	4.2	3.6	5.2	3.2	5.2	4.8	2 2	4 6	1.7	5.5
25.	24.5	12.	15.5	28.5	28	13	17	16	28	13	24	20	12	27.5	8	28.5
5.10	5.40	2.90	3.50	6.20	5.60	3.10	3.80	4.00	6.40	2.90	5.50	4.90	2.60	5.90	1.90	6.30
10.5	8.6	5.	5.1	7.3	8.8	5	5.2	4.9	7.8	3.5	5.5	6.3	4.6	10.2	4	7.4
2.7	2.7	1.6	1.6	2.3	2.2	1.8	2.4	2.1	3.5	1.8	2.2	2.1	1.4	3.2	1.3	3.1
.38	.47	.26	.28	.47	.37	.21	.30	.32	.36	.22	.28	.32	.16	.39	.14	.48
.68	.68	.38	.44	.66	.52	.32	.42	.44	.72	.34	.46	.52	.30	.60	.24	.68
10.5	8.8	9.0	8.4	9.8	13.2	13.0	14.5	11.6	16.0	10.8	15.6	12.7	20.5	12.5	19.5	16.8
2,800	2,850	2,250	2,900	2,800	3,550	4,350	4,000	3,45C	4,550	2,800	4,150	3,200	4,900	4,700	4,300	5,300
11.0	8.8	9.8	8.8	9.4	10.8	14.5	14.0	11.0	13.4	11.2	11.5	10 2	17.0	13.8	14.3	15.5
460	590	1,000	700	450	625	780	760	690	690	850	590	670	570	675	440	490
510	340	210	260	350	380	260	260	275	425	225	400	300	430	240	500	300
7,800	7,800	3,600	8.800	7,000	7,200	5,800	5,400	5,900	8,000	4,000	5,000	5,800	6,000	7,000	6,600	7,000
22	18	14	19.5	18	17	14.5	15	16.5	16	17	17	15	18	14.5	20	17
70	41	44	57	49	50	40	45	50	45	47	45	49	53	42	62	56
3,750	2,250	500	950	1,300	750	700	550	700	1,000	500	700	700	850	700	700	650

Railroad, one including the distance from r 700 miles, that is practically level, as com- the coast, which is very mountainous. The o sections are practically identical in every rly well suited to the conditions under which s and fuel per thousand gross ton-miles on nd district it is 42 cents, due entirely to the

ed in this connection is the fact that this is atisfactory result may be shown which was due to some unusual condition, as, for instance, the cost of fuel on any basis may have run up because of unusual weather conditions, a coal strike or some other labor trouble. The cost of shop tools and machinery may be very high, due to installation of a new shop with a complete new equipment, and so on.

It has been attempted to group the different roads that traverse approximately the same character of country, but in doing this justice has not been possible in every case. Roads which lie in approximately the same district often traverse an entirely different character of country and are subject to the conditions illustrated above. It is believed that with these few warnings our readers will not be misled in using this table, which it is planned to have a regular yearly feature in the future.



POWERFUL MALLET LOCOMOTIVE FOR THE NORTHERN PACIFIC RAILWAY.

HEAVY ARTICULATED LOCOMOTIVES.

NORTHERN PACIFIC RAILWAY.

In 1907 the Northern Pacific Ry. received from the Baldwin Locomotive Works sixteen Mallet locomotives of the 2-6-6-2 type, having a total weight of 351,600 pounds with 313,550 pounds on driving wheels. The performance of these engines in heavy pushing and road service has been eminently satisfactory, and the same company has recently received eleven additional Mallet locomotives from the same works. Five of these engines have the 2-8-8-2 wheel arrangement and are similar in many respects to Southern Pacific locomotives 4000 and 4001, built in the spring of 1909.* The remaining six have the 2-6-6-2 wheel arrangement and are of practically the same capacity as the light Mallets (class L-2) operating on the Great Northern,† although many changes have been made in the details.

2-8-8-2 TYPE.—The Southern Pacific locomotives previously referred to are equipped for oil burning, while the new Northern Pacific engines are coal burners. The firebox has been redesigned, its width being increased from 78¼ to 96 inches, thus enlarging the grate area from 68.4 to 84 square feet. The crown is stayed by radial bolts, and is supported at the forward end from two tee bars hung on expansion links.

The grate is composed of finger bars rocking in four sections, with two drop plates in front. Two sections of bars are placed on each side, and are supported on the center line by a longitudinal bearer of cast steel. The ash pan has three hoppers, with cast iron sliding bottoms of substantial construction.

As in the Southern Pacific locomotives, the boiler is separable with a feed water heater in the front section. The smokebox contains a Baldwin reheater, to which steam is conveyed from the high pressure cylinders by horizontal pipes placed under the running boards. The arrangement of the frames, articulated connection and sliding bearings calls for no special comment. The steam distribution to all the cylinders is controlled by inside admission piston valves, 15 inches in diameter. The low pressure pistons have cast steel bodies and the rods are extended through the front cylinder heads.

2-6-6-2 TYPE.—These engines are not of the heaviest class, and are specially adapted to road service on moderate grades. The details of construction include a number of interesting features.

The steam distribution to all the cylinders is controlled by inside admission piston valves, 13 inches in diameter. As no reheater is used, the high pressure exhaust is conveyed to the low pressure cylinders by a single pipe, placed on the center line of the locomotive. The center of the ball joint at the back end of the receiver pipe coincides with the center of the articulated frame connection, so that the length of the receiver pipe is practically constant under all circumstances. . The cast steel radius bar connecting the front and rear frames is placed below the receiver pipe, and has a forward extension which braces the frames transversely above the main driving pedestals. The hinge-pin is 6 inches in diameter, and is seated in a cast steel cross-tie which spans the lower rails of the rear frames between the high-pressure cylinders. This arrangement provides a strong and simple frame joint, and leaves room for the receiver pipe as well as for the reach rod connecting the high and low-pressure reverse shafts. This reach rod is placed on the center line, and passes through a slot in the high-pressure cylinder saddle.

As in the case of the 2-8-8-2 engines, the low-pressure piston rods are extended through the front heads and all the cylinders are fitted with Sheedy circulating valves as used by the Associated Lines.

The boiler is of the straight topped, radial stay type, and contains 4,014 square feet of heating surface and 53.4 square feet of grate area. The separable joint and feed water heater are omitted. The boiler is supported on the front frames by a single bearer placed between the second and third pairs of driving wheels. The front bearer carries the controlling springs, and normally has a clearance of ½ in. between the upper and lower castings.

The tenders of both classes have 8,000 gallon tanks and are carried on arch-bar trucks with cast-steel bolsters. The wheels are steel tired with cast steel plate centers. The tender frames used with the 2-6-6-2 type locomotives are composed of 12-inch channels, while 13-inch channels are used in the tender frames for the heavier engines.

The principal dimensions of both classes of locomotives are given in the following table:

GENERAL DATA.		
Type	2-8-8-2	2-6-6-2
Gauge	4 ft. 8½ in.	4 ft. 8½ in.
Service	Freight	Freight
Fuel	Bit. Coal	Bit. Coal
Tractive effort	94,640 lbs.	57,760 lbs.
Weight in working order	437,950 lbs.	305,150 lbs.
Weight on drivers	403,800 lbs.	262,350 lbs.
Weight on leading truck	18,750 lbs.	21,500 lbs.
Weight on trailing truck	15,400 lbs.	21,300 lbs.
Weight of engine and tender in working order	590,000 lbs.	455,000 lbs.
Wheel base, driving	39 ft. 4 in.	28 ft. 11 in.
Wheel base, total	56 ft. 7 in.	43 ft. 7 in.
Wheel base, engine and tender	82 ft. 7¾ in.	70 ft. 10½ in.
RATIOS.		
Weight on drivers ÷ tractive effort	4.26	4.56
Total weight ÷ tractive effort	4.63	5.30
Tractive effort × diam. drivers ÷ heating surface	840.00	785.00
Total heating surface ÷ grate area	76.60	75.00
Firebox heating surface ÷ total heating surface, %	3.90	4.94
Weight on drivers ÷ total heating surface	62.50	65.10
Total weight ÷ total heating surface	68.00	76.00
Volume equiv. simple cylinders, cu. ft.	28.84	17.10
Total heating surface ÷ vol. equiv. cylinders	223.00	235.00
Grate area ÷ vol. equiv. cylinders	2.91	3.12
CYLINDERS.		
Kind	Compound	Compound
Diameter	26 and 40 in.	20 and 31 in.
Stroke	30 in.	30 in.
VALVES.		
Kind	Piston	Piston
Diameter	15 in.	13 in.
WHEELS.		
Driving, diameter over tires	57 in.	55 in.
Driving, thickness of tires	3½ in.	3½ in.
Driving journals, main, diameter and length	11 x 12 in.	9½ x 12 in.
Driving journals, others, diameter and length	10 x 12 in.	9½ x 12 in.
Engine truck wheels, diameter	30 in.	30 in.
Engine truck journals	6 x 12 in.	6 x 12 in.
Trailing truck wheels, diameter	30 in.	30 in.
Trailing truck, journals	6 x 12 in.	6 x 12 in.
BOILER.		
Style	Straight	Straight
Working pressure	200 lbs.	210 lbs.
Outside diameter of first ring	84 in.	74 in.
Firebox, length and width	126 x 96 in.	116⅛ x 66¼ in.
Firebox plates, thickness	⅜ and ½ in.	⅜ and ½ in.
Firebox, water space	5 in.	5 in.
Tubes, number and outside diameter	401—2¼ in.	310—2¼ in.
Tubes, length	21 ft.	21 ft.
Heating surface, tubes	4,941 sq. ft.	3,816 sq. ft.
Heating surface, firebox	252 sq. ft.	198 sq. ft.
Heating surface, total evaporating	5,193 sq. ft.	4,014 sq. ft.
Feedheater heating surface	1,220 sq. ft.	——
Reheater heating surface	655 sq. ft.	——
Heating surface, total	6,413 sq. ft.	4,014 sq. ft.
Grate area	84 sq. ft.	53.4 sq. ft.
TENDER.		
Wheels, diameter	33 in.	33 in.
Journals, diameter and length	5½ x 10 in.	5½ x 10 in.
Water capacity	8,000 gals.	8,000 gals.
Coal capacity	13 tons	13 tons

* See AMERICAN ENGINEER, May, 1909, pp. 181.
† See AMERICAN ENGINEER, June, 1907, pp. 213.